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PREDICTING PLANE TRAFFIC WHILE TAKEOFF AND LANDING USING QUEUE MODEL AS THE MEASUREMENT OF ATC SERVICE LEVEL AT ADISUTJIPTO INTERNATIONAL AIRPORT YOGYAKARTA

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ABSTRACT

This research aims to know the number of air plane traffic increase at Adisutjipto International Airport Yogyakarta until 2025, to know the average number of air plane traffic during rush hour at Adisutjipto International Airport Yogyakarta, and to know the service level of Air Traffic Control towards the air plane when takeoff and landing at Adisutjipto International Airport Yogyakarta. The researcher used Microsoft Excel and manual calculation in processing the data.

The research results showed that the estimation of the number of plane traffic at Adisutjipto International Airport Yogyakarta experienced increase in 2018 with total plane traffic 78376 until 2025 it will increase with total plane traffic reaching 103209. The average number of air plane traffic when takeoff and landing at Adisutjipto International Airport Yogyakarta reach 9 planes in one hour. The service level of ATC at normal condition obtained result 15% while during rush hour reach 80%. The average number of air plane queueing at normal condition is 1 air plane per hour while during rush hour is 3 air planes per hour. The average number of air plane in the system during normal condition is 1 air plane per hour, while during rush hour is 4 air planes. The average time spent for waiting for the queue at normal condition is 4,57 minutes/air plane, while during rush hour reached 16 minutes/air plane. The average time spent for waiting in the system during normal condition is 8,57 minutes/air plane, while during rush hour is 20 minutes/air plane.

Kata Kunci : *Queue, Takeoff, Landing, Air Traffic Control, Air Plane*

Introduction

Almost all airports in Indonesia shows the increase in the traffic of passengers as users of air transportation services, this is a positive development impact of air transportation technology and the increasing public confidence in air transport transportation services, including the Yogyakarta Adisutjipto International Airport. Adisucipto Airport also shows a very rapid increase in airplane traffic anually, it is noted that in one day Yogyakarta Adisutjipto International Airport undergoes an average of 172 takeoff and landing aircplanes, it is not yet included Adisutjipto Airport services as a civil inclave airport that has to serve military flights in public transport aircraft, combat aircraft, and training aircraft as a base for training the TNI air force pilot cadres. The number takeoff and landing planes at Yogyakarta Adisutjipto International Airport is quite high, this will cause adverse impacts in flight operations and aircraft queues to enter takeoff and landing services. Generally, the queue happens when the number of customers who comes has exceeded the number of service facilities available, causing customers to wait or queue to be served, the waiting situation is one part of the situation that happens in a series of random operational activities in the service facility. This is explained that the queue happens when the number of customers who come has exceeded the number of existing service facilities, causing customers to wait or queue to be served, the waiting situation is one part of the situation that happens in a series of random operational activities in the facility service (Kakiay, 2004). To find out the further size of the queue, it is used queuing theory approach as a measurement of service level at ATC Adisucipto Airport while to determine the estimated number of airplane traffics using the forecasting method.

Method and Material

Forecasting

forecasting was a process of estimating the situation in the future by using data in the past (Adam and Ebert, 1982). Awat (1990) explained that forecasting was an activity to find out the variables described (dependent variable) value in the future by studying the independent variables in the past, it was by analyzing data patterns and extrapolating for future values. The quantitative forecasting method was explained by Supranto (2000) which consisted of consideration method, regression method, trend method, input output method, and econometrics method. Trend method used a function such as regression method with X variable that showed time.

Time Series

Time series was a data collection that was a historical data in a certain time period. Data that could be used as a time series had to be chronological, which meant that the data had to have sequential time periods. For example, the company sales data during 2006-2011, the data were sales in 2006, in 2007, in 2008, in 2009, in 2010 and in 2011. Time series data was the data that was collected, noted, or observed all the time in sequence. Time periods could use years, quarters, months, weeks, days or hours. Time series was analyzed to find past variations patterns. Time series analysis was used to forecast events in the future based on the previous time series.

Trend

Trend was a long-term traffic that had a tendency to one direction, whether it was the up or down direction. (Atmajaya, 2009). Trend was a long-term upward or downward tendency traffic that was obtained from the average change over time and the value was quite flat or smooth. (Purwanto S.K., 2011). Trend Moment method used the different equation to the half-average method to estimate the values of a and b in equation:

$$Y = a + bx \tag{2.1}$$

The value of a and b can be obtained from linear regression as follows:

$$a = \frac{(\sum Y).(\sum X^2) - (\sum X).(\sum XY)}{n.(\sum X^2) - (\sum X)^2} \tag{2.2}$$

$$b = \frac{n.(\sum XY) - (\sum X).(\sum Y)}{n.(\sum X^2) - (\sum X)^2} \tag{2.3}$$

Two above equations, then to obtaine the value of a and b. On the moment method, X value on trend equation was calculated by making the first data as a base year and value of X = 0.

Table 2.1 Trend amoemnt method

No	Tahun	Total aircraft movement Y	X	X.Y	X²
1	2011	123	0	0	0
2	2012	134	1	134	1
3	2013	254	2	508	4
4	2014	240	3	720	9
5	2015	312	4	1248	16
6	2016	347	5	1735	25
7	2017	375	6	2250	36
	∑	1785	21	6595	91

Source: Data processed

Queue theory

Queue theory was a theory that involved a mathematical study of queues or waiting lines. The formation of waiting lines was an obvious common phenomenon that happened when the need for a service exceeded the available capacity of service facility. Decisions regarding the amount of capacity had to be determined, even though it was actually impossible to make an accurate prediction of when were the customers who need the service going to come and how long it would take to serve. (Dimyati, 2002). According to Nova Tiana Ningsih (2011) there were two queue model basic functions which were: (1) minimized the direct cost, and (2) minimized the indirect cost.

Queuing System Elements

There were many queuing system elements and each of them could be distinguished based on the behavior. The elements of the queueing system were: (1) Queue Input, (2) Arrival pattern, (3) Service mechanism, (4) Service discipline, (5) Output.

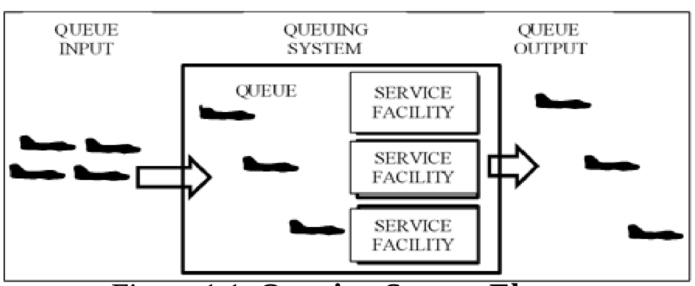


Figure 1.1. **Queuing System Elements**
Source: Data processed

Queue Input was a collection of people or goods from which units came to get service. This collection of people or goods might be finite or infinite.

1. Arrival Pattern,
2. Queue Discipline,
3. Service Level,
4. Output

Queue Structure
Queue structure was differentiated based on the service process, which were Channel and Phase. According to A.K. Erlang (1910) there were some queue system model which were: (1) Single Channel - One Phase, (2) Single Channel – Multi Phase, (3) Multi Channel – One Phase, and (4) Multi Channel - Multi Phase.

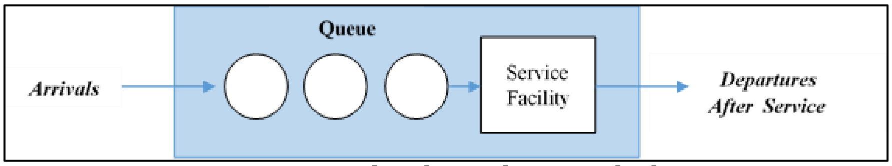


Figure. 2.7 *Single Channel – Singel Phase*

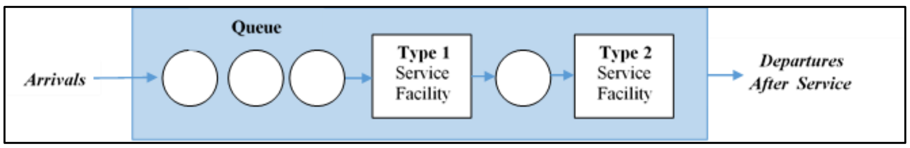


Figure.2.8 Single Channel-Multi Phase

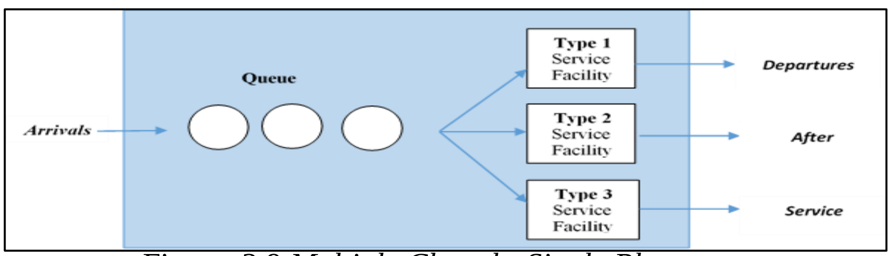


Figure. 2.9 *Multiple Chanel - Single Phase*

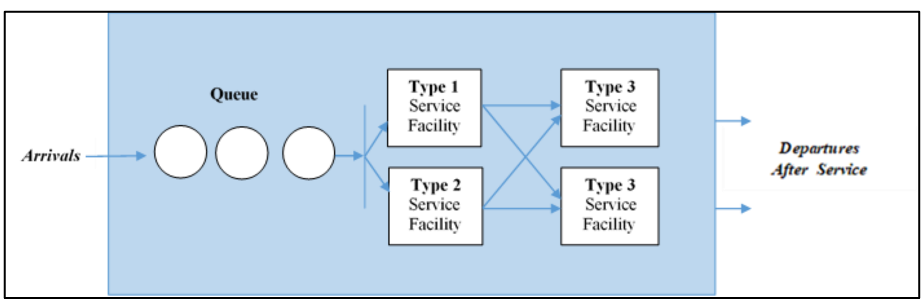


Figure. 2.10 *Multiple Chanel – Single Phase*

Queue Model
Queue Model Assumption
The queuing models that were going to be discussed use assumptions as follows:
a. Distribution of customer arrivals follows the poisson distribution (random).
b. The service discipline follows the FCFS/FIFO guidelines/first comes first served.
c. The single service phase/only has one path to enter the service system

1. The Queue Models

a. M/M/1/I/I Model

This model shows certain queue model with arrival following poisson distribution, the service level which follows exponential probability distribution with:

1.One service,
2.Infinite source of population, and
3.Unlimited length of queue

The formula for solving the problem with model 1 is as follow:

a.The level of service facility usage (The probability of a customer must wait)

$P = \frac{\lambda}{\mu}$ (Formula 2.8)

λ = the level of average arrival
μ = the level of average service

b. The probability of no individual in the queue system (probability of the server is not busy (idle).

$P_0 = 1 - \frac{\lambda}{\mu}$ (Formula 2.9)

λ = the level of average arrival
μ = the level of average service

c.The number of individual in the total system (the queue and service facility)

$Ls = \frac{\lambda}{\mu - \lambda}$ (Formula 2.10)

λ = the level of average arrival
μ = the level of average service

d. The number of average individual in the queue

$Lq = \frac{\lambda^2}{\mu(\mu - \lambda)}$ (Formula 2.11)

λ = the level of average arrival
μ = the level of average service

e.The average time in the queue

$Wq = \frac{\lambda}{\mu(\mu - \lambda)}$ (Formula 2.12)

λ = the level of average arrival
μ = the level of average service

f. The average time in total system

$Ws = \frac{1}{\mu - \lambda}$ (Formula 2.13)

λ = the level of average arrival
μ = the level of average service

b. 2 M/M/S/I/I Model

This model shows certain model with arrival following poisson distribution, the service level follows exponential probability distribution with:

1) the number of server is more than one,
2) infinite source of population, and
3) unlimited length of queue

The formula for solving the problem with model 2 is as follows:

a) The level of service facility usage (The probability of air plane must wait).

$$P = \frac{\lambda}{S\mu} \qquad \text{(Formula 2.14)}$$

λ = the level of average arrival
μ = the level of average service
S = the number of service facility

b) The probability of there is no flight in the queue system (probability of pilot service (idle).

$$P_o = \frac{1}{\sum_{n=0}^{n=S-1}\left[\frac{\left(\frac{\lambda}{\mu}\right)^n}{n!}\right] + \frac{\left(\frac{\lambda}{\mu}\right)^S}{S!\left(1-\frac{\lambda}{S\mu}\right)}} \qquad \text{(Formula 2.15)}$$

S = the number of service facility
λ = the level of average arrival
μ = the level of average service

c) Probability of busy service

$$P_w = \left(\frac{\lambda}{\mu}\right)^S . \frac{P_o}{S!\left(1-\frac{\lambda}{S\mu}\right)} \qquad \text{(Formula 2.16)}$$

S = the number of service facility
λ = the level of average arrival
μ = the level of average service
Po = the probability of no individual in the system

d) The number of individual in the total system (queue and service facility)

$$Ls = Po.\frac{\left(\frac{\lambda}{\mu}\right)^S\left(\frac{\lambda}{S\mu}\right)}{S!\left(1-\frac{\lambda}{S\mu}\right)^2} \qquad \text{(Formula 2.17)}$$

Po = probability of no individual in the system
S = the number of service facility
λ = the level of average arrival
μ = the level of average service

e) The average number of individual in the queue

$$Lq = Ls + \frac{\lambda}{\mu} \qquad \text{(Formula 2.18)}$$

Ls = the number of individua in the total system (queue and service facility)
λ = the level of average arrival
μ = the level of average service

f) The average time in the queue

$$Wq = \frac{Lq}{\lambda} \quad \text{(Formula 2.19)}$$

Lq = the average number of individual in the queue
λ = the level of average arrival

g) The average time in the total system

$$Ws = Wq + \frac{1}{\lambda} \quad \text{(Formula 2.20)}$$

Wq = the average time of queue
λ = the level of average arrival

c. 3 M/M/1/F/I Model

This model shows certain queue model with arrival following poisson distribution, the service level which follows exponential probability distribution with:

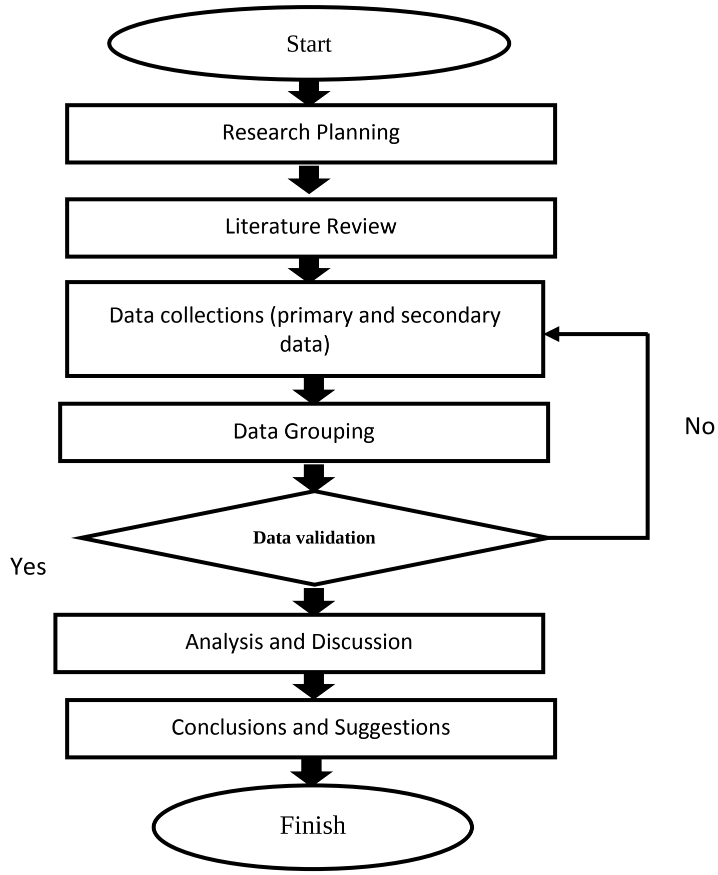
1) One service,
2) Limited source of population (finite),
3) Unlimited length of queue

d. 4 M/M/S/F/I Model

This model showed the queuing model with the arrival followed the Poisson distribution, the level of service that followed the exponential probability distribution with 1) the number of services was more than one, 2) finite population source, and 3) queue length was also infinite.

Probability Distribution

1. Poisson Distribution: Poisson distribution described the number of success that happned during a certain time interval or in a certain area. The time interval was measured in seconds, minutes, hours, days, and etc. (Walpole, 1995)
2. Exponential Distribution: Exponential Distribution was a test conducted to make estimations or predictions that only estimated the population average, because an exponential distribution had a standard deviation which is equal to the average. This exponential distribution was widely used in the field of statistics, especially in the mainstay theory and queuing theory. If service time meets an exponential distributionn in queuing theory.



Flow diagram

Result and Discussion

Aircraft Traffic at Yogyakarta Adisutjipto International Airport.

It is obtained the aircraft traffic at Yogyakarta Adisutjipto Airport from 2011 to 2017. Graphically, the aircraft traffic at Yogyakarta Adisutjipto International Airport has increased from 2011 to 2013 and has decreased in 2014 and then has increased until 2017. It is clearer to be seen in the graphic image as follows:

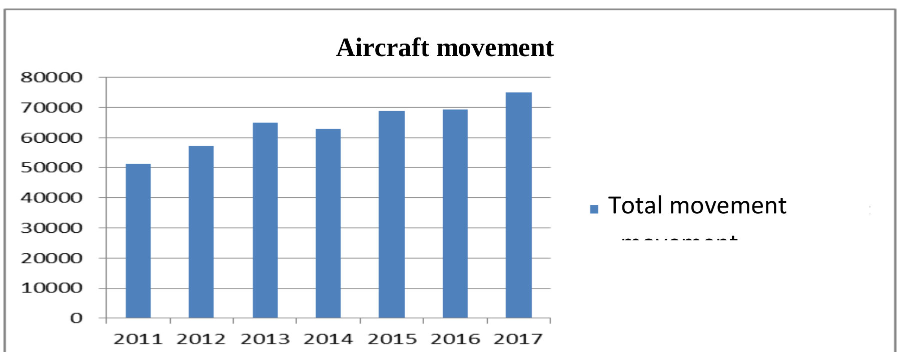


Figure 4.1 Graph Aircraft Movements

Forecasting of Aircraft Traffic

To complete the forecasting calculation of aircraft traffic in the further time, the following calculation steps are going to be conducted as follows:

Processed Data Table 4.2 Forecast

NO	Year	Total aircraft movement	X	X.Y	X²
		Y			
1	2011	51212	0	0	0
2	2012	57225	1	57225	1
3	2013	64925	2	129850	4
4	2014	62918	3	188754	9
5	2015	68729	4	274916	16
6	2016	69266	5	346330	25
7	2017	75027	6	450162	36
	∑	**449302**	**21**	**1447237**	**91**

Source: Data processed

From the table above, it is known that n = 7, then the number of aircraft traffics at Yogyakarta Adisutjipto International Airport in 2018 to 2025 can be predicted by the linear regression equation as follows: $Y = a + bX$

Where a value is obtained by the formulation:

$$a = \frac{(\sum Y).(\sum X^2) - (\sum X).(\sum XY)}{n.(\sum X^2) - (\sum X)^2}$$

$$a = \frac{(449302).(91) - (21).(1447237)}{6.(91) - (21)^2}$$

$$a = \frac{40886482 - 30391977}{637 - 441}$$

$$a = \frac{10494505}{196}$$

$$a = 53543,4$$

And b value is obtained by through formula:

$$b = \frac{n.(\sum XY) - (\sum X).(\sum Y)}{n.(\sum X^2) - (\sum X)^2}$$

$$b = \frac{7.(1447237) - (21).(449302)}{7.(91) - (21)^2}$$

$$b = \frac{10130659 - 9435342}{637 - 441}$$

$$b = \frac{19566001}{196}$$

$$b = 3547,5$$

Therefore to calculate the forecast in the upcoming year by using linear regression as follows:

$$Y = a + bX$$
$$\boldsymbol{Y = 53543,4 + 3547,5\ X}$$

To obtain the forecast value of plane traffic estimation in 2018 with X value = 7 then the plane traffic in 2018 is as follows:

$$Y = a + bX$$
$$Y = 53543,4 + 3547,5\ .\ X$$
$$Y = (53543,4) + (3547,5)\ x\ (7)$$
$$Y = 78375,9$$

Y ≈78376 air plane per year

By the same way, an estimated number of aircraft traffics are going to be obtained at Yogyakarta Adisutjipto International Airport in 2018 until 2025 based on the linear regression equation are seen in the following:

Table 4.3 Prediction of the Total Aircraft Traffic

Year	X Value	Aircraft Movements
2018	7	78376
2019	8	81924
2020	9	85471
2021	10	89019
2022	11	92566
2023	12	96114
2024	13	99661
2025	14	103209

By the forecast calculation result above, it can be concluded that the aircraft traffic in Yogyakarta Adisutjipto International Airport from 2018 to 2025 is increasing anually. Such as shown in the following graphic:

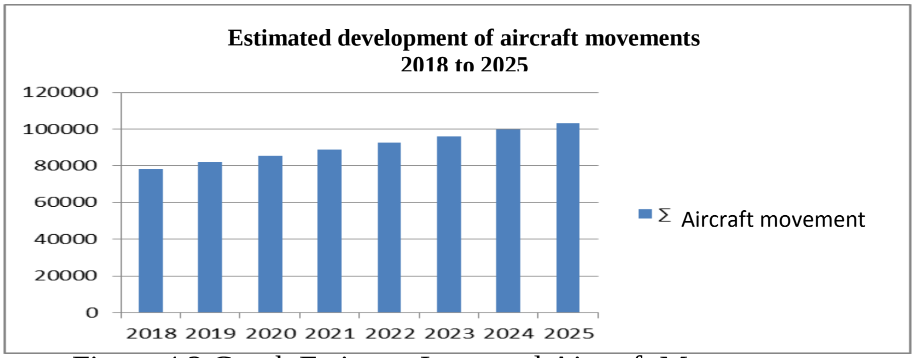


Figure 4.2 Graph Estimate Increased Aircraft Movements

Calculating Air Traffic Control (ATC) Service Level with Queue System Calculations. Average Number of Aircraft Traffics

The average level of aircraft traffic at Yogyakarta Adisutjipto Airport is considered as busy if the number of traffics per hour reaches 12 to 15 aircrafts, whereas it is considered normal if the number of aircraft traffics is below 12 aircrafts per hour. From the calculation results of the aircraft traffics number at Yogyakarta Adisutjipto International Airport on January 1, 2018 to January 31, 2018, the results for an average aircraft traffic per hour are as follows:

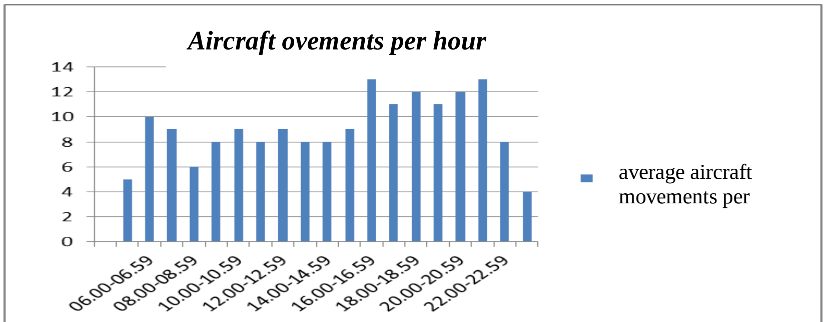


Figure 4.3 graphs average aircraft movements per hour

Calculating Time Takeoff and Landing Time

1. Time Takeoff and Climb

Motion segment consists of the takeoff roll and climb to 1500 feet which refers to the boundary segment of the takeoff climb to 1500 feet. Calculation of takeoff time taken to three different types of aircraft that is

(A) Light weight aircraft (less than 7000 kg)
(B) Small aircraft weight (7000 kg-18500 kg, and
(C) Medium weight Aircraft (more than 18500-155000 kg)
Which operates in Yogyakarta.

a. *Light weight aircraft,*

$V_{reaching\ speed} = a\ x\ t$

With the known V reaching speed for the aircraft below 7000 kg, as the plane with the category A is 65 knots with propulsion average aircraft known to 14500 kgf (Jeppsen - Turbulence Aircraft Weight Category), then the average acceleration time of the takeoff roll by;

$Thrust = aircraft\ mass\ x\ accelerate\ moving$

$$Accelerate\ moving = \frac{Thrusst}{aircraft\ mass}$$

$$Accelerate\ moving = \frac{14500\ kgf}{7000\ kg}$$

$Accelerate\ moving$ = 2,05 m / sec^2

Then the time of the takeoff roll:

$$t = \frac{V_{reaching}}{a}$$

V reaching speed = 65 knots
V reaching speed = (65 x 1,852 x 1000/3600) meter / second
V reaching speed = 33.438 meters / sec
So the best time during the takeoff roll until liftoff of

$t = \frac{33,348}{2,05}$

$t = 16,276$

≈ 16 seconds

$time\ climb = \frac{altitude}{rate\ of\ climb}$

Altitude = 1500 feet as the minimum safe height limit or the Minimum Safe Altitude (MSA)

Rate of climb: 450 feet / minutes

$time\ climb = \frac{1500}{450}$

$time\ climb$ = 3.3 minutes

≈ 3.3 minutes

So the time of the takeoff and climb = 16.3 sec + 3.3 minutes

= (16.3 / 60) minutes + 3.3 minutes

= 3.57 minutes

b. *Small aircraft weight,*

$V_{reaching\ speed} = a\ x\ t$

With the known V reaching speed for the aircraft above 7000 kg s / d 18 500 kg, As the plane with category B is 91 knots with propulsion average aircraft known to 32500 kgf (Jeppesen - Turbulence Aircraft Weight Category).

The average weight of 14500 kg air

Then the average acceleration time of the takeoff roll by

$Thrust = aircraft\ mass\ x\ accelerate\ moving$

$Accelerate\ moving = \frac{Thrusst}{aircraft\ mass}$

$Accelerate\ moving = \frac{32500\ kgf}{14500\ kg}$

$Accelerate\ moving$ = 2,24 m / sec^2

Then the time of the takeoff roll:

$t = \frac{V_{reaching}}{a}$

V reaching speed = 91 knots

V reaching speed = (91 x 1,852 x 1000/3600) meter / second

V reaching speed = 46.814 meters / sec

So the best time during the takeoff roll until liftoff of

$t = \frac{46,814}{2,24}$

$t = 20,899$

≈ 21 seconds

$time\ climb = \frac{altitude}{rate\ of\ climb}$

Altitude = 1500 feet as the minimum safe height limit or the Minimum Safe Altitude (MSA)

Rate of climb = 550 feet / minutes

$time\ climb = \frac{1500}{550}$
$time\ climb$ = 2,727 minutes
≈ 2.7 minutes
So the time of the takeoff = 21 899 sec + 2.7 minutes
= (16.3 / 60) minutes + 3.3 minutes
= 3.66 minutes

c. *Medium weight aircraft*,
CLARE (reaching speed) = AXT
With the known V reaching speed for the aircraft above 18500 kg s / d 15 500 kg, as with category C aircraft is 121 knots
By plane thrust the average note 121 800 kgf (Jeppesen - Turbulence Aircraft Weight Category).
The average aircraft weight 58000 kg
Then the average acceleration time of the takeoff roll by
$Thrust = aircraft\ mass\ x\ accelerate\ moving$
$Accelerate\ moving = \frac{Thrusst}{aircraft\ mass}$
$Accelerate\ moving = \frac{121800\ kgf}{58000\ kg}$
$Accelerate\ moving$ = 2.1 m / sec²
Then the time of the takeoff roll:
$t = \frac{V_{reaching}}{a}$
V reaching speed = 121 knots
V reaching speed = (121 x 1,852 x 1000/3600) meter / second
V reaching speed = 62.2478 meters / sec
So the best time during the takeoff roll until liftoff of
$t = \frac{62,2478}{2,1}$
$t = 29,641$
≈ 30 seconds
Time climb = Altitude / (rate of climb)
Altitude = 2500 feet as the minimum safe height limit or the Minimum Safe Altitude (MSA)
Rate of climb = 750 feet / minutes
Time climb = 2500 / (750)
Time climb = 3.3 minutes
≈ 3.3 minutes
So that the takeoff time = 30 seconds + 3.3 minutes
= (30/60) min + 3.3 min
= 3.8 minutes

Thus, the average time of the takeoff and climb Lightweight aircraft, aircraft weight Small, Medium and aircraft weight is as follows:

$$= \frac{3{,}57\ menit + 3{,}66\ menit + 3{,}8 menit}{3}$$

= 3.67 minutes

2. Time Approach & Landing

Landing time engineering calculations referring to the guidelines of A & L

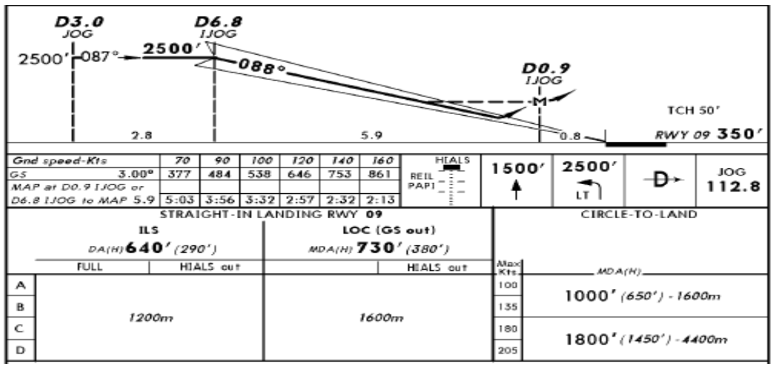


Figure 4.4 Initial Approach

In this, study using Standard Terminal Arrival Procedure (STAR RWY-09). Final Approach When the aircraft on approach initiation position (Initial Approach) at an altitude of 2500 feet at a distance of 6.8 DME with 088 deg direction towards the runway.

Approach to land the vertical velocity variations (Vertical Speed Indicator) ranging from 861 feet / min, 753 feet / min, 646 feet / min, 538 feet / min, 484 feet / min, 377 feet / min.

So the average VSI obtained by calculation

$$= \frac{861 + 753 + 646 + 538 + 484 + 377}{6}$$

$$= 609.83\ feet/min\ ,$$

Time to landing obtained by calculation

$$Time\ to\ land = \frac{2500\ feet}{609.83\ feet/min}$$

$$Time\ to\ land = 4.09\ min$$

Then the average service time of the aircraft during landing is;

= 4.09 minutes

With the above calculation can obtained the maximum number of takeoff and landing services per hour by ATC for

$$= \frac{(3{,}67 + 4{,}09) minutes}{2} = 3{,}88 \frac{minutes}{aircraft}$$

$$= \frac{60}{3{,}88} = 15{,}463$$

Alternatively, 15 aircraft per hour as the maximum level of service (μ).

4.1.1 Finding out the value of ATC service level.

In finding out the Air Traffic Control (ATC) service level in Yogyakarta Adisutjipto International Airport, the calculation steps will be carried out using queuing theory with the queue structure of Single Channel – Single Phase which is only one path to enter the service and only have one servant by using the discipline of first-come first-served (FCFS) or first-in first-out (FIFO) means that those who come first are served, so the calculation uses the M/M/1 queuing model as follows:

Here is the result of the calculation of aircraft movement:

1. Aircraft Movements level (λ) On Not Busy

Table 4.5 Level of Aircraft Movements (λ) On Not Busy

NO	Interval Time	Total	Movements averege
1	00.06 - 06.59	294	10
2	00.07 - 07.59	289	9
3	00.08 - 08.59	197	8
4	00.09 - 09.59	227	9
5	00.10 - 10.59	282	8
6	00.11 - 11.59	249	8
Total		1537	8

μ = 15 aircraft per hour
λ = the level of air traffic with an average of 8 planes

a. To level ATC Services (P)

$$P = \frac{8}{15}$$

P = 0.53 or 53%

b. The average amount of air in the queue ()L_q

$$L_q = \frac{8^2}{15(15-8)}$$

$$L_q = 0{,}609$$

$L_q \approx$ 1 plane

c. The average amount of air in the system (L_s)

$$L_s = \frac{8}{15-8}$$

$$L_s = 1,\ 143$$

$L_s \approx$ 1 plane

d. Average time on air in the queue (.W_q)

$$W_q = \frac{8}{15(15-8)}$$

$$W_q = 0{,}0762 \text{ Hour}$$

$$W_q = 4{,}57 \text{ Minutes}$$

e. Average time on air in the total system (W_s)

$$W_s = \frac{1}{15-8}$$

$W_s = 0.143$ Hour
$W_s = 8{,}57$ Minutes

2. Aircraft Movements level (λ) In the busy Conditions

NO	Interval Time	Total	Movements averege
1	00.16 - 16.59	401	13
2	00.17 - 17.59	350	11
3	00.18 - 18.59	367	12
4	00.19 - 19.59	349	11
5	00.20 - 20.59	362	12
6	00.21 - 21.59	411	13
Total		2240	12

Table 4.6 Level of Aircraft Movements (λ) In the busy Conditions

μ = 15 aircraft per hour
λ = the level of air traffic with an average of 12 aircraft

a. To level ATC Services (P)

$$P = \frac{12}{15}$$

P = 0.80 or 80%

b. The average amount of air in the queue ()L_q

$$L_q = \frac{12^2}{15(15-12)}$$

$L_q = 3{,}2$
$L_q \approx 3$ aircraft

c. The average amount of air in the system (L_s)

$$L_s = \frac{12}{15-12}$$

$L_s = 4$
$L_s \approx 4$ aircraft

d. Average time on air in the queue (.W_q)

$$W_q = \frac{12}{15(15-12)}$$

$W_q = 0.266$ Hour
$W_q = 16$ Minutes

e. Average time on air in the total system (W_s)

$$W_s = \frac{1}{15-12}$$

$W_s = 0.333$ Hour
$W_s = 20$ Minutes

The results explanation of the queuing analysis calculation using the M/M/1 method at runway services at Yogyakarta Adisutjipto International Airport in January 2018 are:

1). Atc service use level (P): The ATC service use average level under normal conditions is 53%, whereas in busy conditions the ATC service use level is 80%.
2) The average number of aircraft in the queue (L_q): The aircraft queue average number in a busy condition is 1 aircraft per hour, while in a busy condition is 3 aircrafts per hour
3) The aircrafts average number in the system (L_s): The aircrafts average number in the system in a non-busy condition is 1 aircraft per hour, while in a busy condition is 4 aircrafts
4) The average time of the aircrafts in the queue (W_q): The average time spent waiting in a queue when conditions are not busy is 4.57 minutes/aircraft, while in busy conditions it is 16 minutes/aircraft;
5) Average aircraft time in the total system (W_s); The average time spent waiting in the system in non-busy conditions is 8.57 minutes/aircraft, while in busy conditions is 20 minutes/aircraft.

From the calculation it can be seen that the problem of the aircraft queue that will takeoff and landing at Yogyakarta Adisutjipto International Airport is only at certain hours while at out of 16.00-21.59 WIB is still enough to serve aircraft that will takeoff and i. So, the ATC service level on aircraft traffics that will takeoff and landing is considered as not yet optimal in service.

Conclusion

According to the data analysis and discussion results that has been done by the researcher, it is found that, (1) the estimated number of aircraft traffics at Yogyakarta Adisutjipto International Airport is increasing from 2018 with the number of aircraft traffics of 78376 until 2025 with the number of aircraft traffics reaching 103209. (2) The average number of aircraft traffics during takeoff and landing at Yogyakarta Adisutjipto International Airport in an hour reaches 9 aircraft. (3) ATC service level in non-busy condition is 50% while in busy conditions is 80%, the average aircraft waiting in a busy condition is 1 aircraft per hour while in a busy condition that are 3 aircrafts per hour, the average number of planes in the system in a non-busy condition is 1 aircraft per hour, while in a busy condition are 4 aircrafts, the average time spent waiting in a queue when conditions are not busy is 4.57 minutes/aircraft, whereas in a busy condition is 16 minutes/aircraft, the average time spent waiting in the system in a non-busy condition is 8.57 minutes/aircraft, whereas in busy conditions it is 20 minutes/aircraft. For suggestion, a review should be conducted regarding the regulation and provision of slot time for aircrafts that are operating at Yogyakarta Adisutjipto International Airport in order to optimize the airport to be more optimal and to improve the convenience of air transport users so as to minimize the queues and accidents that may occur.

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