# ARRIVAL TIME FLIGHT SCHEDULING IN KUALA LUMPUR INTERNATIONAL AIRPORT

Shafeqa Ameera Jufri, Mastura Ab Wahid*, Istas Fahrurrazi Nusyirwan, Shabudin Mat, Md Nizam Dahalan, Shuhaimi Mansor, Wan Khairuddin Wan Ali, Tholudin Mat

School of Mechanical, Faculty of Engineering, Universiti Teknologi Malaysia, 81310UTM Johor Bahru, Johor, Malaysia

*mastura@mail.fkm.utm.my

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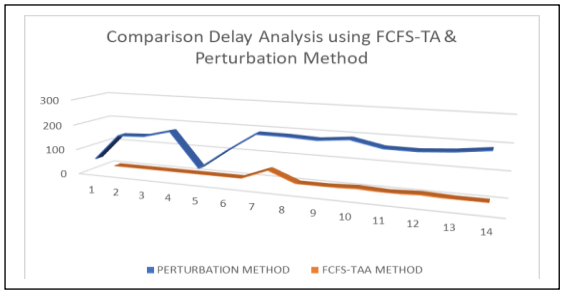
## GRAPHICAL ABSTRACT




## ABSTRACT

*This project aimed to resechdule the flight plan by minimizing the delay of air traffic flow, focusing in the stage of flight arrival. Three modelling for aircraft sequencing and rescheduling for landing was developed and compared. The methods used are First Come First Serve (FCFS), First Come First Serve combined Time-Advance (FCFS+TA), and Perturbation using White Noise Gaussian with Random Variable (Perturbation). Kuala Lumpur International Airport was chosen as the project location. An analysis was developed to observe the implementation of three methods on typical day of operations in year of 2015. The FCFS+TA method revealed the optimization approach for utilizing the runway in KLIA in order to achieve 576 flights per day. Therefore, with using FCFS+TA method, 63% of utilization of both arrival runway in KLIA have been optimized.*

## KEYWORDS

Air Traffic Flow; Rescheduling; First Come First Serve (FCFS); Perturbation; Optimization.

## INTRODUCTION

An air traffic flow management are the solution in improving airspace efficiency and increasing capacity. Air Traffic Flow Management (ATFM) balances the demand with the airport resources and capacity. Air traffic flow management have been initiated in the Eleventh Air Navigation Conference, 2003 in Montreal, Canada on September 22nd to achieve best outcome for the traffic in air. There are many reasons that link to the inefficiency of a flight and one major cause is delay. Delays may be caused by multiple issues such as climate, ground holds and maintenance issues [4, 5, 9]. In the aviation world delay equal to loss of profit, since delay lead to a cascading effect as the subsequent flights need to be delayed, cancelled or reschedule to accommodate for the initial delay. The system that is currently being used in Malaysia, focusing in Kuala Lumpur International Airport (KLIA), is First Come First Serve (FCFS).

FCFS method will give an initial ordering to the flight taking into account its' estimated time of arrival (ETA)s and its' maximum allowable time-advanced. The Time-Advanced method is applied on the first aircraft of each group, and does not change the existing order of the group. The first aircraft in a group is being precede to arrive sooner than its nominal ETA, and all aircraft in the group following it will have their delays decreased by the same amount of time.

Majorly, this method been used widely to sort the arrival of aircraft in KLIA. According to Hang Zhou

and Xinxin Jiang et. al. [24], the FCFS is not the best method to reduce delay and this can be shown with KLIA ranked 40th for most delay airport in Asia region, and have 22.05% on delay [19].

There are five (5) categories of delay defined by The Federal Aviation Administration (FAA). They are gate delay, taxi-out delay, en route (in flight) delay, terminal delay and taxi-in delay. An aircraft is said to be in delay when it requires more time in a regime than what was scheduled.In the early twentieth century, studies on scheduling optimization have been started. According to Hang Zhou and Xinxin Jiang [24], numerous method have be introduced. Some improvement suggested by Roger G. Dear [21] is the dynamic scheduling by using constrained position shifting (CPS) on FCFS while near the terminal area especially during peak hour. This method is called first-come, first-served, runway (FCFSRW) strategy. Then C.R Brinton [22] developed an algorithm known as implicit enumeration (IE). This algorithm takes into account the runway assignment in the planning process. Then scheduling combining mixed integer program and branch and bound is proposed by J. Abela et.al. [23]to reduced delay during landing.

Flight assignment and schedule can help in reducing delay and increase numbers of flight. Moreover, numerous airport in other country enhance capacity by expanding the quantity of runways, along these lines lessening the flight delay [2, 3, 10 and 13]. Flight delay can be alleviated effectively by utilizing the runway resource. As can be seen, the delay in KLIA have a total of 22.05% delay and they are using FCFS system to manage the traffic flow which might not be the best tools for the current air traffic. Therefore, in this paper, we would like to measure and analyze the delay during arrival in KLIA and to propose methods to reduce the delay. The aim of this study is to minimize the delay on the air traffic flow. Several objectives were established to achieve the stated study aims as follows; - To analyze the historical data of air traffic flow for year 2015 using statistical approach; To reschedule flight plan on the arrival time to optimized both runways in KLIA.

## METHODOLOGY

This study covers common techniques used in the analysis of historical data of air traffic flow for year 2015 and the techniques used to reschedule flight plan to optimize both runways in KLIA. The techniques will be incorporated in the proposed assessment procedure which is the core finding of the study.

### Data Collection

In order to fulfil the objective of the study, the most important information is the historical data of air traffic flow for year 2015 (flight plan). This study will extract the flight plan which been gathered from the Department of Civil Aviation Malaysia (DCA). All the provided data from flight plan is used as the input parameter in statistical analysis and rescheduling the flight plan analysis.

### Data Analysis using Basic Mathematical Model FCFS

The used of mathematical model is to generate the time for arrival aircraft in WMKK. The calculation of arrival time is used to sort number of arrival aircraft within 24 hours, and to get clear display view on the same arrival time aircraft that been assumed using 2 runway on the same time. However, if there's more than two aircraft arrive on the same time, then the third aircraft will be assumed as delay. The equation is performed as below.

$$T_{a,j} = T_{D,i} + D_{f,i} \quad (1)$$

where; $T_{a,j}$=arrival time, $T_{D,i}$= departure time, $D_{f,i}$= duration of flight, $i$ = No of aircraft, $j$ = no of runway and j=1,2.

### First Come First Serve (FCFS) + Time-Advance Algorithm (TA)

The combination of FCFS and Time-Advance algorithm schedules the aircraft and puts out arrays of aircraft data that are in order of scheduled time of arrivals (STA). The calculation include the time advance, where on this project we assume the time advance should not be more than 60 minutes

$$0 \leq TA < 60 \text{ minutes};$$

To get the $T_{a,RS}$(Resheduled Estimated Landing Time), the equation to get the result are as followed;

$$T_{a,RS} = T_{a,j} + TA \quad (2)$$

Then, the interval time between flights that need to be assume for every aircraft that lands on the runway are as followed;

$$T_{a,RS}\,(n+1)) = T_{a,RS} + 0{:}05 \text{ minute} \quad (3)$$

where; $T_{a,RS}$= Rescheduled estimated landing time using FCFS+TA, $T_{a,j}$ = Actual Arrival Time and TA = Time Advanced

### Perturbation FCFS+TA using White Noise Gaussian with Random Variable

The result for time arrival obtained using FCFS+TA method are being used to get the result if adding perturbation to the flight plan. This method is being generated to analyze what-if there is any sudden delay occur. The equation used to generate the perturbation time of arrival results as follow;

$$pG\,(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(z-\mu)^2}{2\sigma^2}} \quad (4)$$

where z is probability time of delay.The equation used to get the rescheduled estimated landing time via Perturbation is;

$$T_{a,RPS} = T_{a,RS} + z \quad (5)$$

where; $T_{a,RPS}$= Reschedule Estimated Perturbation Landing Time, $T_{a,RS}$= Estimated landing time using FCFS+TA method and z = Probability time of delay

## Results and Analysis

An outline of rescheduling flight plan data that have been extracted from actual flight plan report. The acquired flight plan data from is provided by Department of Civil Aviation Malaysia (DCAM). The general information of flight plan for year 2015 tabulates in Table 1.

Table 1 : General information of flight plan

| *Flight Plan Information* | *Total* |
|---|---|
| Day for Analysis over 2015 year | 14 Days |
| Number of Arrival Flight over 2015 year | 4665 Flights |
| % of Arrival Flight over 2015 year | 57.85% |
| Year of Analysis | 2015 |
| No of Arrival Runway | 2 |
| | RWY 32<br>RWY 14 |

### First Come First Serve (FCFS) Overall Result Analysis

Figure 1 shows analysis of total number of aircraft using First Come First Serve (FCFS) method, the method that is being used currently in DCAM. From the bar chart above, the orange line is the maximum number of flight per day. The maximum number of flight if we fully utilized both runway, will be 576 flights per day. From FCFS method, we can make the analysis of total number of aircraft landed in KLIA within the fourteen (14) days are as table 2 follows:

Table 2 : Analysis for the FCFS Method

| | |
|---|---|
| *Total number of landed aircraft on the WMKK runway* | **4665 flights** |
| *Average number of landed using FCFS Method* | **334 flights** |
| *Total number to fully utilised the runway using 5 mins interval* | **7704 flights** |
| *Percentage of the utilisation of FCFS Method* | **60.56%** |

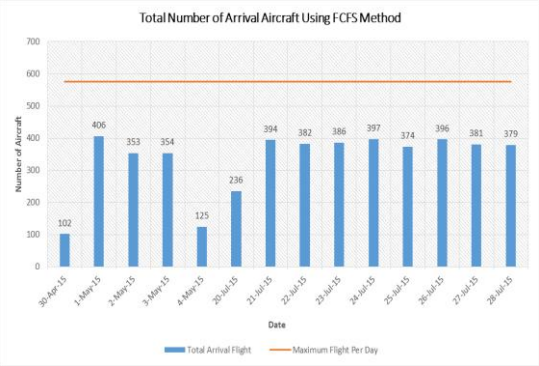



Figure 1 : Total Number of Aircraft Using FCFS Method

### First Come First Serve (FCFS) + Time-Advance Overall Result Analysis

Figure 2 shows analysis of total number of aircraft using First Come First Serve (FCFS) with Time-Advance method. From the bar chart above, the orange line is the maximum number of flight per day. The maximum number of flight if we fully utilized both runway, will be 576 flights per day. From FCFS+TA method, we can make the analysis of total number of aircraft landed in KLIA within the fourteen (14) days are as table follows:

Table 3: Analysis for the FCFS+TA Method

| | |
|---|---|
| *Total number of landed aircraft on the WMKK runway* | **4824 flights** |
| *Average number of landed using FCFS Method* | **344 flights** |
| *Total number to fully utilised the runway using 5 mins interval* | **7704 flights** |
| *Percentage of the utilisation of FCFS +TA Method* | **62.62%** |

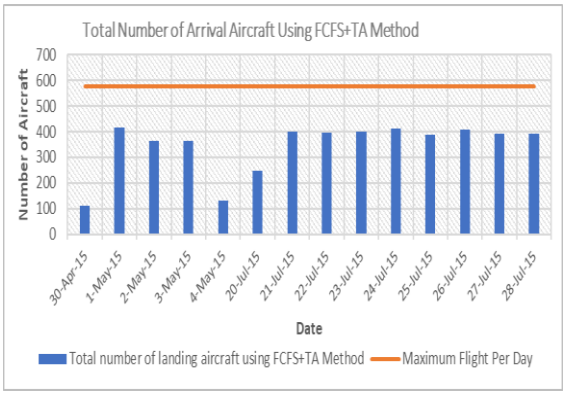



Figure 2 : Total Number of Aircraft Using FCFS Method

## Perturbation using white noise Gaussian with random variable % number of arrival flight

Figure 3 shows analysis of total number of aircraft using Perturbation method. From the bar chart above, the orange line is the maximum number of flight per day. The maximum number of flight if we fully utilized both runway, will be 576 flights per day. From Perturbation method, we can make the analysis of total number of aircraft landed in KLIA within the fourteen (14) days are as table follows:

Table 4 : Analysis for the Perturbation Method

| | |
|---|---|
| *Total number of landed aircraft on the WMKK runway* | **4818 flights** |
| *Average number of landed using FCFS Method* | **344 flights** |
| *Total number to fully utilised the runway using 5 mins interval* | **7704 flights** |
| *Percentage of the utilisation of Perturbation Method* | **62.56%** |

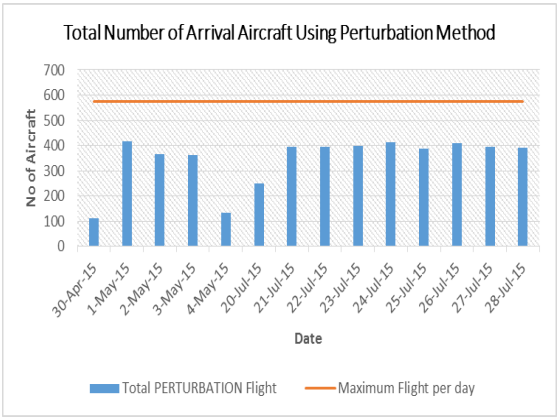



Figure 3: Total Number of Aircraft Using FCFS Method

## Comparison Total Landing Time when using FCFS, FCFS+TA and Perturbation Method

Based on the tabulation bar chart analysis on Figure 4, it shows that using method FCFS+TAreduces the delay than when using only FCFS method. However, when there is a perturbation, the FCFS+TA do suffers from unscheduled operation such as climate change. For example taking FCFS+TA and Perturbation method from 20th to 28th July 2015, with FCFS+TA only 54 number of delays will occurred. However, when there is perturbation, the total number of delay for these 9 days are 1754, where it will lead to inefficient used of runway.The result also shows that Perturbation method will reduce the effectiveness of FCFS+TA method by average of 51.63% as in figure 5.

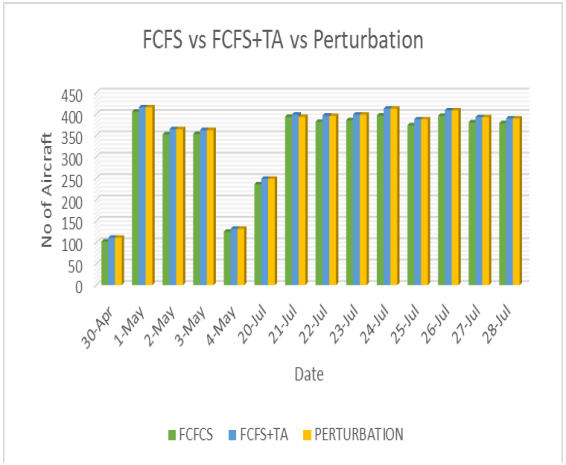



Figure 4: Bar Charts on Analysis Comparison of total number using 3 different method

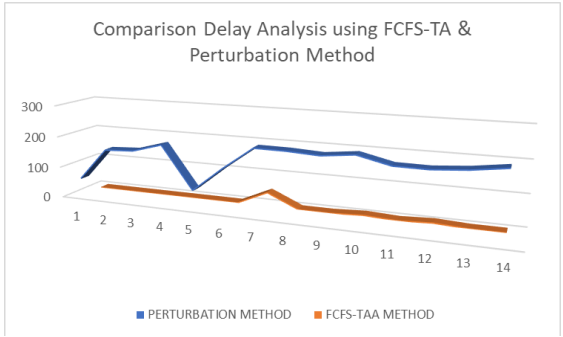



Figure 5: Effect of Perturbation on FCFS+TA

## CONCLUSION

It can be concluded that the proposed study work has been successfully accomplished in accordance with study aims. All findings have fulfilled the main goal of this study, which is to minimize the delay on the air traffic flow. The achievements from this study work can be summarized accordingly into research objectives.

The comparison of the model was analysed with respect to the basic version FCFS, which only considers the arrival flow. We measured how much the total amount of time were impacted by

changes in the following parameters: set of discrete delays/time advance and separation time interval. Flight plan have been rescheduled to optimize both runways using three method, FCFS, FCFS+TA and Perturbation Method.

Among the results of the total number of flights throughout year 2015 within the 14 days, we observed that there is increasing of number when applied the method of FCFS combine with TA. We also observed that relaxing the FCFS+TA benefits 63% in terms of utilizations of both of the runway. Thus, for airport with low level of fleet heterogeneity, we can consider that FCFS+TA sequencing strategy is still the best option as it keeps the fairness criterion between aircraft.

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