**COMPARATIVE ANALYSIS OF RUNWAY CAPACITY CALCULATION  
USING FEDERAL AVIATION ADMINISTRATION (FAA) METHOD  
AND AIRCRAFT OPERATION MODELING DEVELOPMENT METHOD  
STUDY CASE: RUNWAY 3 OF SOEKARNO-HATTA INTERNATIONAL AIRPORT**

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## Abstract

*Airports are a part of the transportation service system that is growing rapidly in this modern era. Economic growth and development need a fast, safe, and timely service system. This condition results in high demand for air transportation, which affects the number of flight schedules.*

*Runways are the most important and valuable company asset for airport operators, such as PT Angkasa Pura II (Persero) (AP2). The high investment needed to build and maintain the runway has resulted in the necessity for special attention to AP2 management. One of the important things in runway management is related to runway capacity in accommodating aircraft movements within a certain period. Soekarno-Hatta International Airport, the largest airport operated by AP2, has two parallel runways, each 3,600 and 3,660 meters long and 60 meters wide. In 2018, Soekarno-Hatta International Airport was in a condition of overcapacity in aircraft movement on the airside. Due to that reason, AP2 decided to build a new runway called Runway 3.*

*In the construction of Runway 3, an analysis of the runway capacity calculation is needed to see how Runway 3 supports the increased aircraft movements.* *It is essential to determine whether Soekarno-Hatta International Airport can overcome its capacity problems and determine when the problems may occur to help the management determine its business strategy.*

*We conducted this research using historical data of aircraft movement patterns on Runway 1 and Runway 2 from 2008-2018. The secondary data used in this study are acquired from PT. Angkasa Pura II (Persero) and Jakarta Air Traffic Service Center (JATSC) using linear regression in forecasting movements to obtain the number of aircraft movements that occur in the planned year (2023 and 2028). The aircraft movement forecasting results are then converted into the runway’s aircraft movement capacity at peak hours using the Pignataro’s and NPIAS methods. We obtained the aircraft movement capacity in the planned year after converting aircraft movements with the FAA and the aircraft operation modeling development method.*

*Using the FAA method, the results show that in 2020 Runway 3 will still accommodate aircraft movements during peak hours until 2023, while overcapacity is expected to occur in 2027. However, according to the aircraft operation modeling development method, Runway 3 will experience overcapacity starting in 2020. Improvements and optimizations are needed so that Runway 3 capacity in the coming year can accommodate the aircraft movement.*

***Keyword****: Airport, Runway 3, Capacity, FAA Method, Mixed Operation Method*

1. **BACKGROUND**  
   The transportation system links passengers, goods, facilities, and infrastructure. It also has a role in the mobilization of people or goods from one place to another accordingly. In achieving an optimal and efficient transportation system, there needs to be an integrated technology development for the transportation system.

Airports are a part of the transportation service system that has experienced rapid development in this modern era. They consist of extensive and complex transportation facilities designed to serve aircraft, passengers, cargo, and other vehicles. Facilities at airports are generally classified into two categories based on their location; the airside, which includes runway, taxiway, and apron; and the landside, including the terminal building, parking facilities, and commercial area.

Runways are the most important and valuable company asset for airport operators, such as PT Angkasa Pura II (Persero) (AP2). The high investment value needed to build and maintain runways has resulted in the necessity for special attention to AP2 management. Currently, the high public demand for flight services makes the flight schedules of all airlines increasingly tight. It results in the increasing need for runway capacity, which must continue to adjust to the number of flights. If not handled thoughtfully, overcapacity will happen. It is already happening at the Soekarno-Hatta International Airport. With the existing conditions—two parallel runways, each 3,600 and 3,660 meters long and 60 meters wide—AP2 decided to build a new runway called Runway 3.

Because of the reasons stated above, an analysis of the runway capacity calculation is needed to see how Runway 3 can support the increased aircraft movements. In this study, two calculation methods are used in determining the base capacity; these are the FAA (Federal Aviation Administration) method and the aircraft operation modeling development method. It is essential to determine whether Soekarno-Hatta International Airport can overcome its capacity problems and determine when the problems may occur to help the management determine its business strategy.

1. **RESEARCH PURPOSES**
   1. To determine the optimum capacity and the number of aircraft movements that Runway 3 can accommodate during peak hours.
   2. To determine the benefits of calculating Runway 3’s optimum capacity for AP2’s strategic investment.
   3. To determine the number of aircraft movements that Runway 3 can accommodate at peak hours for the operational activities efficiency at the BSH airside.
2. **LITERATURE REVIEW**

**Airport**  
An airport is a defined area on land or water (including any buildings, installations, and equipment) intended to be used—either entirely or partly—for the arrival, departure, and surface movement of aircraft (Annex 14, ICAO 2013).

**Runway**

A runway is a facility, usually pavements, prepared for aircraft landings and take-offs.

**Airport Capacity**

According to Horonjeff (2010), there are two computations of capacity: ultimate capacity and practical capacity. The maximum capacity does not involve calculating delays and reflects the airfield’s ability to accommodate aircraft during the given period, such as at peak times. On the contrary, practical capacity involves calculating delays.  
  
**Runway Capacity Calculation Method**

1. FAA Method

Besides ICAO, the Federal Aviation Administration (FAA) guides calculating runway capacity for different aircraft compositions, different runway configurations, and different taxiway exit locations. This guide is contained in the FAA Advisory Circular (AC) 150 / 5060-5. Airport Capacity and Delay (1983) with revisions in 1995. Runway capacity is calculated based on mixed operating modeling based on the operating rules below:

1. An arrival has priority over a departure.
2. Only one plane can be on the runway at a time.
3. A departure cannot be carried out if the next plane arriving is less than a certain distance from the runway threshold, usually 2 NM (nautical miles) under IFR conditions.
4. Sequential departures are carried out so that the minimum time separation is the same as the departure service time.
5. Aircraft Operation Modeling Development Method

This method is developed by Horonjeff, which consists of several models that are useful in determining the maximum number of aircraft operations that a runway can accommodate within a certain period when there is a continuous service request. In these models, capacity is the same as the reverse weight of the average service time of all aircraft served. Grounding service time is defined as separation in air shown by the time of runway use.

1. **RESEARCH METHOD**

**Flow Chart Runway 3 Capacity Analysis**

**Literature Review**

**Data Collection**

1. Aircraft Passenger Data for 2008-2018
2. Aircraft Movement Data for 2008-2018
3. Detailed Engineering Design (DED) Runway 3
4. Mixed Type Aircraft Data using Runway
5. Daily Flight Schedule Data on The Peak Month of 2018
6. Data on Aircraft and Passenger Movements Every Month in 2018

**Analysis and Discussion**

Runway 3 Capacity (aircraft operation modeling development method, FAA method, forecasting conditions in 5 and 10 years)

**Conclusion and Recommendation**

**Problems Identification**

**Data Processing**

Analysis of Runway 3 Capacity Calculation (Aircraft operation modeling method, FAA method, forecasting conditions 5 years and 10 years)

**Research sites**

We conducted this research at the Soekarno-Hatta International Airport, which is located in Tangerang, Banten.

**Research Material**

This study contains an analysis of Runway 3 capacity at the time of initial publication and a forecast on Runway 3 capacity in the next 5 and 10 years using the FAA and the aircraft operation modeling development method.

**Research time**

Data collection was carried out from January to April 2019, while data processing was carried out from February to June 2019.

1. **ANALYSIS & DISCUSSION**

**Airplane Movement Growth Forecast**

Historical data on aircraft movements at Soekarno-Hatta International Airport is required in predicting the growth of aircraft movements until the planned year, which is 2023 and 2028. Forecasting aircraft movement is used to calculate the runway capacity in the planned year. The aircraft movement at Soekarno-Hatta International Airport during 2008-2018 is shown in Table 5.1 below

**Tabel 5.1** Existing Aircraft Historical Data

in North and South Runway

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Operation** | | | **%** |
| **Arrival** | **Departure** | **Total** |
| 2008 | 133,798 | 116,375 | 250,173 |  |
| 2009 | 135,208 | 112,871 | 272,877 | 9% |
| 2010 | 157,528 | 148,013 | 305,541 | 12% |
| 2011 | 174,500 | 171,008 | 345,508 | 13% |
| 2012 | 191,900 | 189,220 | 381,120 | 10% |
| 2013 | 201,295 | 198,135 | 399,430 | 5% |
| 2014 | 197,436 | 193,548 | 390,984 | -2% |
| 2015 | 195,433 | 191,182 | 386,615 | -1% |
| 2016 | 209,394 | 204,387 | 413,781 | 7% |
| 2017 | 226,292 | 221,098 | 447,390 | 8% |
| 2018 | 234,365 | 228,706 | 463,071 | 4% |

Source: PT. Angkasa Pura II (Persero), 2019

Based on the extrapolation results using the Microsoft Excel Help Program, we obtained the equation and R2 for linear regression, summarized in Table 5.2.

**Tabel 5.2** The Equation and R2 for Each Movement

Based on Linear Regression Analysis

|  |  |  |
| --- | --- | --- |
| **Operation** | **Equation** | **R²** |
| Arrival | y = 10611x + 125640 | 0.8655 |
| Departure | y = 13043x + 106351 | 0.8316 |

We obtained the forecasting results by entering the value of n as the forecasting year in each regression equation, such as the following example:

* 1. The regression equation for the number of arrival aircraft movements is y = 10611x + 125640
  2. 2023 is the 16th year of plan (n), so x = 16, y16 = 10611 (16) + 125,640 = 295,416 arrival aircraft movements.

The predictions of aircraft movements on the Soekarno-Hatta International Airport Runway in 2019-2028 is shown in Table 5.3.

**Tabel 5.3** Forecasting Aircraft Movements on Runway

In 2019 - 2028

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **Year Order  (x)** | **Arrival** | **Departure** | **Total** | **%** |
| 2019 | 12 | 252,972 | 262,867 | 515,839 | 33% |
| 2020 | 13 | 263,583 | 275,910 | 539,493 | 5% |
| 2021 | 14 | 274,194 | 288,953 | 563,147 | 4% |
| 2022 | 15 | 284,805 | 301,996 | 586,801 | 4% |
| **2023** | **16** | **295,416** | **315,039** | **610,455** | **4%** |
| 2024 | 17 | 306,027 | 328,082 | 634,109 | 4% |
| 2025 | 18 | 316,638 | 341,125 | 657,763 | 4% |
| 2026 | 19 | 327,249 | 354,168 | 681,417 | 4% |
| 2027 | 20 | 337,860 | 367,211 | 705,071 | 3% |
| **2028** | **21** | **348,471** | **380,254** | **728,725** | **3%** |

Based on the aircraft movements prediction of the Soekarno-Hatta International Airport Runway, the forecasted aircraft movements in 2023 is 610,455; both arrival and departures grow by 4% from 2022. Meanwhile, the forecasted aircraft movement in 2028 is 728,725; both arrival and departures grow by 3% from 2027.

**Analysis of aircraft movements at peak hours**

After obtaining the forecasted number of aircraft movements in the planned year, we calculated the movement volume at peak hour conditions. This calculation is done to determine the aircraft’s maximum movement level at peak hour conditions and as a basis for reference to the maximum aircraft movements that can be accommodated by the runway. The method used to calculate the movement at peak hours is the Pignataro (peak ratio) and the NPIAS method.

1. **Pignataro Method**
2. **Peak Month Ratio**

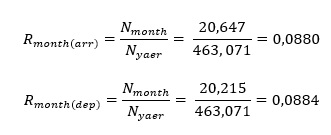
**Tabel 5.4** Aircraft Movements per Month on

Soekarno – Hatta International Airport Runway in 2018

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Month** | **Operation** | | **Total** | **%** |
| **Arrival** | **Departure** |
| January | 19,757 | 19,243 | 39,000 |  |
| February | 17,633 | 17,226 | 34,859 | -11% |
| March | 19,499 | 19,054 | 38,553 | 11% |
| April | 19,794 | 19,272 | 39,066 | 1% |
| May | 18,896 | 18,356 | 37,252 | -5% |
| June | 20,456 | 19,936 | 40,392 | 8% |
| **July** | **20,647** | **20,215** | **40,862** | **1%** |
| August | 20,264 | 19,776 | 40,040 | -2% |
| September | 19,536 | 19,063 | 38,599 | -4% |
| October | 20,050 | 19,620 | 39,670 | 3% |
| November | 18,729 | 18,289 | 37,018 | -7% |
| December | 19,104 | 18,656 | 37,760 | 2% |
| **Total** | **234,365** | **228,706** | **463,071** |  |

Source: PT. Angkasa Pura II (Persero), 2019

Peak arrival month ratio (R*month*(*arr*)) is the number of aircraft arrivals in July divided by the total number of movements in 2018, while the peak month departure ratio (R*month*(*dep*)) is the number of aircraft departures in July divided by the total number of movements in 2018.



1. **Peak Day Ratio**

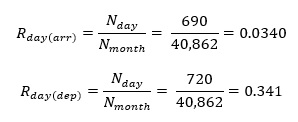
**Tabel 5.5** DailyAircraft Movements on

Soekarno – Hatta International Airport Runway in July 2018

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Day** | **Departure** | **Arrival** | **Day** | **Departure** | **Arrival** |
| **1** | 637 | 643 | **17** | 648 | 657 |
| **2** | 649 | 653 | **18** | 651 | 666 |
| **3** | 662 | 680 | **19** | 661 | 657 |
| **4** | 670 | 684 | **20** | 662 | 683 |
| **5** | 624 | 639 | **21** | 667 | 683 |
| **6** | 633 | 638 | **22** | 660 | 680 |
| **7** | 639 | 663 | **23** | 668 | 676 |
| **8** | 624 | 637 | **24** | 669 | 684 |
| **9** | 628 | 641 | **25** | 664 | 681 |
| **10** | 664 | 667 | **26** | 674 | 678 |
| **11** | 644 | 655 | **27** | 664 | 676 |
| **12** | 631 | 650 | **28** | **690** | **702** |
| **13** | 635 | 639 | **29** | 671 | 684 |
| **14** | 672 | 679 | **30** | 646 | 656 |
| **15** | 643 | 666 | **31** | 661 | 670 |
| **16** | 636 | 648 | **Subtotal** | **20247** | **20615** |
| **Total** | | | | **40862** | |

Source: PT. Angkasa Pura II (Persero), 2019

The peak day arrival ratio is obtained from the number of aircraft arrivals divided by the number of aircraft movements in December.



1. **Peak Hour Ratio**

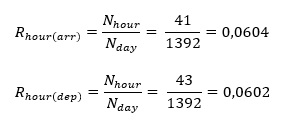
**Tabel 5.6** Aircraft Movements per Hour on

Soekarno – Hatta International Airport Runway on 28 July 2018



Source: PT. Angkasa Pura II (Persero), 2019

The peak hour ratio (Rhour) is the total number of aircraft movements in one hour at 14.00-14.59, divided by the total number of aircraft movements on Thursday, 28 July 2019.



1. **Determining the Peak Time in 2023 and 2028**

We can calculate the aircraft peak time movement by multiplying the total annual aircraft movement (year - n) due to forecasting with each ratio of months, days, and hours above.

1. **NPIAS Method**

This method is used to calculate aircraft movements that “touch and go” at peak hours.

**Tabel 5.7** “Touch & Go” Aircraft Movements on

Soekarno – Hatta International Airport Runway in 2018

**A screenshot of a cell phone

Description generated with very high confidence**

Source: Jakarta Air Traffic Service Center, 2019

Based on the data above, the touch and go movements at peak hours on Runway 25 and Runway 07 can be found using equations with the following calculations:

**Runway 25:**

Average monthly aircrafts

= 0,08417 x 909 = 76,51

Average daily aircrafts

= 0,03226 x 76,51 = 2,47

Peak-day flow

= 1,26 x 2,47 = 3,11

Peak-hour flow

= 0,0917 x 3,11 = 0,28

**Forecasting Aircraft Class Mixing Percentage**

Through the classification of aircraft types based on the MTOW, approach speed category, and data on the number of aircraft movements on the Soekarno-Hatta International Airport runway, we can see the mixture percentage of aircraft classes based on these two categories. Aircraft movement data is based on types available from 2008 to 2018. In the approach speed category, the percentage of planes taken into account is the percentage of aircraft arrivals since the data will be used to calculate mixed operation runway capacity in the Modelling Development of Aircraft Operation method. The following are the results of forecasting the mixed percentage of aircraft classes:

**Tabel 5.8** Forecasting Percentage ofAircraft Class Mixing

based on MTOW Category In 2019 - 2028



**Tabel 5.9** Forecasting Percentage ofAircraft Class Mixing

based on Approach Speed Category In 2019 - 2028



**Runway 3 Capacity Calculation**

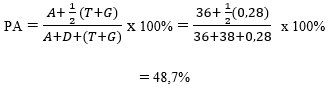
1. **FAA Method**

The steps to determine runway capacity based on the FAA method are as follows:

1. Determine the runway use configuration
2. Calculate the value of the mixed index

%(C+3D) = (93 + 3(7)) = 114%

1. Calculate the arrival percentage



1. Determine the C\* value

The mixing index amounted to 114%, and the arrivals percentage amounted to 48.7%. If the two values are put together in one line (FAA table), then a C \* value of 59 movements per hour will be obtained (IFR condition).

1. Determine the touch and go (T) value

Value 1 is taken because all flights are carried out under IFR conditions

1. **A close up of a sign

   Description generated with high confidence**Determine the exit factor (E) value

The exit taxiway distance from the threshold with the mix runway index 25 of 114% is 5000 ft - 7000 ft from the 25 runway threshold. Furthermore, we must determine the number of runway exits at that distance interval. The number of runway exits at a distance of 5000 ft - 7000 ft from the end of the runway threshold 25, there is no runway exit. Therefore, based on FAA provisions, with 48.7% arrival and four exit runways, the value of the exit factor obtained is equal to 1.

1. Calculate the runway capacity per hour

C = C\* x E x T

An analysis of the aircraft’s movement on the runway at peak hours for existing conditions and the projected conditions in the next 5 and 10 years, using the FAA method, obtain the following results.

**Tabel 5.10** Runway 3 Capacity per Hour based on FAA Method

|  |  |
| --- | --- |
| **Runway Capacity Per Hour** | |
| **2018 (Existing)** | **59** |
| 2019 | 60 |
| 2020 | 60 |
| 2021 | 60 |
| 2022 | 62 |
| **2023** | **62** |
| 2024 | 62 |
| 2025 | 62 |
| 2026 | 62 |
| 2027 | 62 |
| **2028** | **62** |

1. **Modelling Development of Aircraft Operation**

We calculated runway capacity in modeling development, assuming that the runway will only accommodate the arrivals with the aircraft mixed-method formula as follows.

The following are the Runway 3 of Soekarno-Hatta International Airport’s capacity calculation with the Modelling Development of Aircraft Operations method.

**Tabel 5.11** Runway 3 Capacity based on Modelling Development  
of Aircraft Operations Method

|  |  |
| --- | --- |
| **Runway Capacity Per Hour** | |
| **2018 (Existing)** | **46** |
| 2019 | 46 |
| 2020 | 46 |
| 2021 | 46 |
| 2022 | 46 |
| **2023** | **46** |
| 2024 | 46 |
| 2025 | 46 |
| 2026 | 46 |
| 2027 | 46 |
| **2028** | **46** |

**Comparison of Runway 3 Capacity to Aircraft Movements in Peak Hour**

**Table 5.12** Comparison of Runway 3 Capacityto Aircraft Movements in Peak Hour



Based on the table above, we can conclude that in the existing conditions, the runway can still accommodate aircraft movements during peak hours, as shown by both methods. The FAA method also indicates that it will still accommodate aircraft movements during peak hours in 2023. As for aircraft movements in 2023, the modeling development of the aircraft movement method indicates that overcapacity will occur. Both methods also show that, in 2028, aircraft movements will also experience the same thing. As seen in the colored blocks, based on the FAA method, Runway 3 will start experiencing overcapacity in 2027. Meanwhile, based on mixed operations, Runway 3 has been experiencing overcapacity since 2020.

1. **CONCLUSION & RECOMMENDATION**
2. According to the FAA method, the optimum Runway 3’s capacity at Soekarno-Hatta International Airports is 60 movements per hour, whereas according to the aircraft operation modeling development method, the Runway 3’s capacity at Soekarno-Hatta International Airport is 46 movements per hour.
3. For runway capacity, according to the calculation results using the FAA method, Runway 3 of Soekarno-Hatta International Airport will experience overcapacity in 2027, whereas using mixed operation method modeling, overcapacity will occur in 2020. We suggest that AP2 start thinking about what investment strategies should be taken to solve the overcapacity problem in 2027. For example, AP2 can add a new runway, optimize the existing runways by setting the flight slot time, or even moving several flights to the nearest airport such as Halim Perdana Kusuma Airport.
4. Using the FAA Method or the mixed operation modeling, Runway 3 can accommodate aircraft movements during peak hours in 2023. Nevertheless, AP2 should consider making the flight operations effective so that no flight queue is too long on taxiways because, in addition to disrupting flight operations, it can also reduce passenger satisfaction.

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