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EVALUATION OF COMPLIANCE WITH THE RUNWAY OCCUPANCY TIME STANDARD AT SOEKARNO-HATTA INTERNATIONAL AIRPORT

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Abstract: The research aims to calculate the runway occupancy time (ROT) at Soekarno-Hatta International Airport. ROTs are crucial in calculating the runway capacity, which can influence the time it takes for the aircraft to exit the runways after landing or enter a runway before take off. This may have an impact on the quantity of aircraft that utilize the runway for take offs and landings within an hour. The Runway Occupancy Time calculation model, which is the Doratask model in the Runway Capacity Calculation Manual, is employed in this study along with quantitative methodologies. The data collection techniques used are observations, documentation studies and interviews. The results of this study showed that the average ROT at Soekarno-Hatta International Airport was 5.36 seconds slower than the standard, which is 95.36 seconds for ROTT, and 0.37 seconds faster than the standard, which is 54.63 seconds for ROTL.

Keywords: Air Traffic Flow Management, Runway Occupancy Time, Doratask

Introduction

Air transportation is a crucial component of the modern transportation system. The study of the characteristics of air traffic becomes highly significant. Air traffic refers to the number of aircraft passing through a specific point or route within a given period.(Wang et al., 2011)

Air transportation is inherently tied to airports, defined as facilities for aircraft takeoff and landing (International Civil Aviation Organization, 2016). Every airport has a runway, and larger ones also feature facilities like terminals and hangars, serving the needs of flight service operators and users(Horonjeff et al., 2010).

Over the past decade, affordable flights have rapidly expanded air transportation in Indonesia, causing a surge in passenger numbers and transforming aviation dynamics(Suprianto et al., 2020). This growth has led to crowded activities at airports, with limited capacity resulting in queues and delays, impacting subsequent flights. The key limiting factor for runway capacity is the Runway Occupancy Time (ROT). In airports with restricted capacity, various methods aim to reduce ROT and meet the growing demand for air transportation (Horonjeff et al., 2010).

According to (Kolos-Lakatos & Hansman, 2013), several factors influence the Runway Occupancy Time (ROT): 1) Runway Layout (runway exits, length of runway), 2) Size and type of aircraft using the runway, 3) Weather conditions, and 4) Air Traffic Control (ATC) regulations related to separation.

Factors influencing runway usage, including airport, aircraft, and airline characteristics, such as runway system configuration, taxiway setup, exit size and distance, and apron area, need analysis(Ruhl, 1988). Other factors like traffic routes, aircraft size, weather conditions, and wake

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vortex build-ups, as well as arrival and departure procedures, should also be considered in this assessment(Di Mascio et al., 2020).

Additionally, every modification to airport capacity is influenced by and dependent on the environmental policies of airport operators and social and transportation organizations (Cokorilo & Dell'Acqua, 2013). Therefore, reliable methods can be developed to reduce Runway Occupancy Time (ROT) through the optimization of runway exit systems (N. P. Meijers, 2019).

In the book "Airport Engineering"(Ashford et al., 2013), it is explained that the key to airport layout is the taxiway system, connecting the runway to the terminal, gate apron area, and aircraft services in hangars. In the design and layout of taxiways, the primary emphasis is to ensure the smooth flow and efficiency of aircraft along the taxiway.

Furthermore, optimizing schedules significantly reduces total taxi time and can avoid potential flight conflicts, thereby greatly enhancing airport operational efficiency (Liu et al., 2011).

Excessive waiting time for aircraft on the runway can limit the number of flights the airport can handle and impact overall airport operational efficiency (International Civil Aviation Organization, 2018). Additionally, prolonged waiting times can also affect passenger experiences and diminish their satisfaction with airport services.

Soekarno-Hatta International Airport is the largest airport in Indonesia and serves as the main hub for both international and domestic air traffic in the country. However, operational issues arise regarding the time it takes for aircraft to vacate the runway after landing or before takeoff (Runway Occupancy Time - ROT). If the ROT exceeds established standards, it can increase the risk of collisions and flight delays, impacting the airport's capacity and operational costs. The evaluation of ROT is crucial as there are concerns that frequently occurring ROT may not meet the established standards, potentially causing flight delays or even aircraft accidents, affecting passenger safety and comfort.

Evaluation is crucial to determine how ongoing programs are performing, measure the outcomes of the implementation conditions, and investigate whether the executed programs align with the intended goals (Robert & Brown, 2004). If not, it puts us in a position to either halt or improve the programs. This necessary investigative process is referred to as evaluation (Nuriyah, 2014).

Currently, according to the AIP, Soekarno-Hatta Airport has standard ROTT and ROTL times of 90 seconds for ROTT and 55 seconds for ROTL. This standard was published in 2022, and there have been no recent calculations regarding runway occupancy time.

Based on the background description above, the researcher is interested in conducting an evaluation of the Runway Occupancy Time (ROT) at Soekarno-Hatta International Airport, which will be compared to the ROT standards set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta). This evaluation of runway occupancy time (ROT) is also expected to serve as supporting data for calculating the overall runway capacity of Soekarno-Hatta International Airport when utilizing all three runways.

Method

This research employs a survey and quantitative method, involving direct observation in the ATC Tower cabin at Soekarno-Hatta International Airport to collect Runway Occupancy Time (ROTT and ROTL) data. Secondary data collection includes examining ASMGCS and ADS-B data recordings during peak traffic conditions. The population consists of all category C and D aircraft landing and taking off at Soekarno-Hatta Airport, while the sample includes all aircraft landing and taking off during peak hours. The following are the data instruments used in the research:

1. Runway Occupancy Time Takeoff (ROTT),
2. Runway Occupancy Time Landing (ROTL),
3. ROT based on category,
4. ROT based on type of aircraft,
5. ROT based on airline
6. Peak hours data

Following the DORATASK (Indonesia, 2015) method and Ministry of Transportation regulations, analyzing Runway Occupancy Time (ROT) for one runway requires 7 days of aircraft movement data. ROTT is calculated from runway entry to crossing the imaginary threshold boundary, while ROTL is calculated from crossing the imaginary threshold boundary to runway exit.

In the data processing phase, this research refers to an evaluation model by comparing the calculated Runway Occupancy Time (ROT) results with the standard Runway Occupancy Time (ROT) values established based on aircraft category, type of aircraft, and airline.(N. Meijers & Hansman, 2019)

Discussion

1. Research Result

According to the guidelines of the AirNav Indonesia Manual - Runway Capacity Calculation, which the researcher used as the basis for this study, at least two sets of observation data are required as primary data, namely runway occupancy time and flying time. The focus of this research is on fixed-wing aircraft in categories C and D. Data collection is carried out in accordance with the runway usage at Soekarno-Hatta International Airport.

The Arithmetical Mean Runway Occupancy Time (AMROT) is derived by averaging the sum of the Mean Runway Occupancy Time for takeoff (MROTT) and Mean Runway Occupancy Time for landing (MROTL), obtained through observational activities. Runway Occupancy Time (ROT) values are categorized into two: 1) ROT for takeoff is the duration from crossing the runway stopbar during takeoff until passing the end of the runway. 2) ROT for landing is the duration from crossing the threshold at the beginning of the runway until passing the runway vacated sign. The following are the results of the researcher's calculation of Arithmetical Mean Runway Occupancy Time (AMROT) based on aircraft categories:

Table 1. Survey Value Results

CAT	RUNWAY 25R						
	ROTT	**AIRCRAFT**	**MROTT**	**ROTL**	**AIRCRAFT**	**MROTL**	**AMROT**
C	9393	98	95,84694	4919	75	55,58667	**70,7168**
D	5780	62	93,22581	5478	85	54,44706	**68,83643**
	RUNWAY 07L						
	ROTT	**AIRCRAFT**	**MROTT**	**ROTL**	**AIRCRAFT**	**MROTL**	**AMROT**
C	6450	68	94,85294	4453	67	56,46269	**70,65781**
D	4814	52	92,57692	3432	53	54,75472	**68,66582**
	RUNWAY 25L						
	ROTT	**AIRCRAFT**	**MROTT**	**ROTL**	**AIRCRAFT**	**MROTL**	**AMROT**
C	7453	77	96,79221	4688	69	57,94203	**72,36712**
D	4093	43	95,18605	3385	51	56,37255	**70,7793**
	ROTT	**AIRCRAFT**	**MROTT**	**ROTL**	**AIRCRAFT**	**MROTL**	**AMROT**
	RUNWAY 07R						
C	9799	101	97,0198	6941	102	58,04902	**72,53441**

D	5617	59	95,20339	3907	58	57,36207	**71,28273**

Based on the table above, the values of ROTT, ROTL, and also the AMROT values of each runway at Soekarno-Hatta can be determined.

2. Discussion

From the observations conducted, the researcher analyzed the achievement or compliance of the operator in adhering to the standard Runway Occupancy Time, both for Runway Occupancy Time Take Off (ROTT) and Runway Occupancy Time Landing (ROTL). The problem analysis based on the obtained data is as follows:

a) Analysis of runway occupancy time compliance level based on *wake turbulence category*

1) Runway occupancy take off time (ROTT) compliance level

From the observation results, it was found that out of the 560 observed departure aircraft, 344 were in the wake turbulence category C, and 216 were in the wake turbulence category D.

Out of the 344 aircraft with wake turbulence category C, observed for Runway Occupancy Time Take Off (ROTT), 80 aircraft met the standard, while 264 aircraft did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

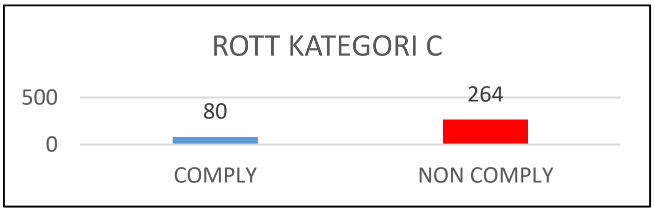

Figure 1. Number of ROTT Category C Aircraft

In summary, from the observed data of aircraft in wake turbulence category C, 23% met the standard for Runway Occupancy Time Take Off (ROTT), while 77% did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

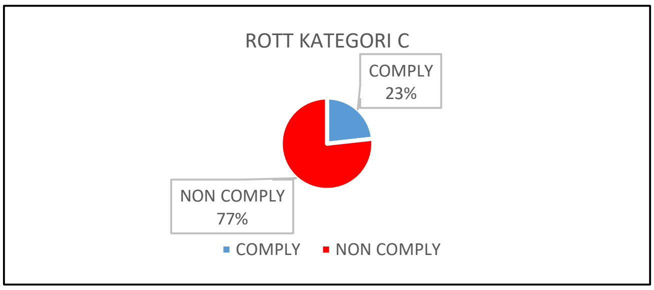

Figure 2. Category C Aircraft ROTT Compliance Level

On the other hand, out of the 216 observed aircraft in wake turbulence category D, 75 aircraft met the standard for Runway Occupancy Time Take Off (ROTT), while 141 aircraft did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

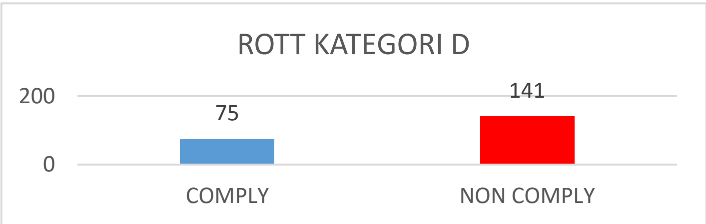

Figure 3. Number of ROTT Category D Aircraft

In summary, from the observed data of aircraft in wake turbulence category D, 35% met the standard for Runway Occupancy Time Take Off (ROTT), while 65% did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

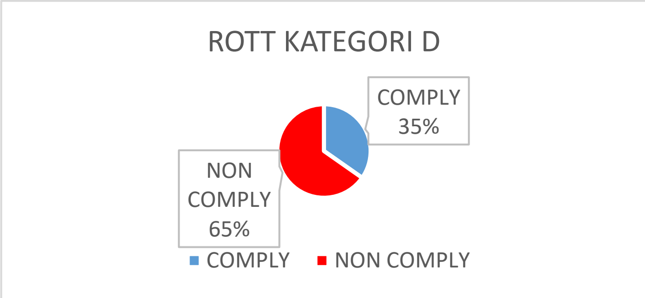

Figure 4. Category D Aircraft ROTT Compliance Level

2) Runway occupancy landing time (ROTL) compliance level

From the analysis results, it was found that out of the 560 observed arrival aircraft, 313 were in the wake turbulence category C, and 247 were in the wake turbulence category D.

Out of the 313 aircraft with wake turbulence category C, observed for Runway Occupancy Time Landing (ROTL), 174 aircraft met the standard, while 139 aircraft did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

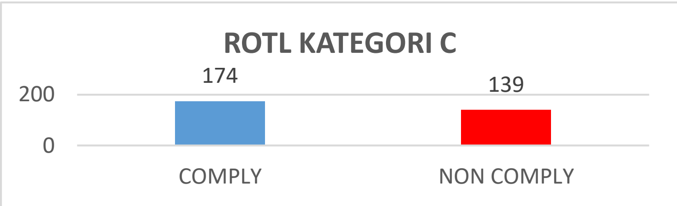

Figure 5. Number of ROTL Category C Aircraft

In summary, from the observed data of aircraft in wake turbulence category C, 56% met the standard for Runway Occupancy Time Landing (ROTL), while 44% did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

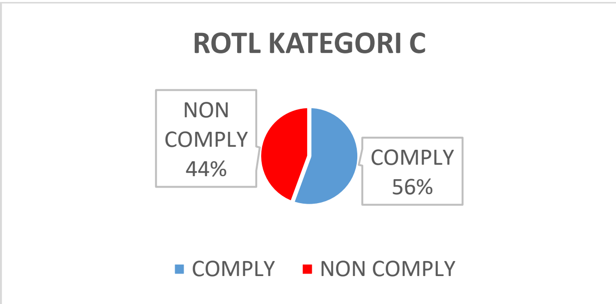

Figure 6. Category C Aircraft ROTL Compliance Level

b) Analysis of runway occupancy time compliance level based on *type of aircraft*

1) Runway occupancy take off time (ROTT) compliance level

From the analysis results, it was found that out of the 560 observed departure aircraft, the most common aircraft types were the A320 family and B737 family. There were 300 aircraft from the A320 family and 198 aircraft from the B737 family. Additionally, 62 other aircraft belonged to different types such as B777, B787, A330, A350, and other jet engine types.

Out of the 300 A320 family aircraft observed for Runway Occupancy Time Take Off (ROTT), 76 aircraft met the standard, while 224 aircraft did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

For the B737 family aircraft, out of the 198 observed, 72 aircraft met the standard for Runway Occupancy Time Take Off (ROTT), while 126 did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

Regarding other jet engine types, out of the 62 observed aircraft, 7 met the standard for Runway Occupancy Time Take Off (ROTT), while 55 did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

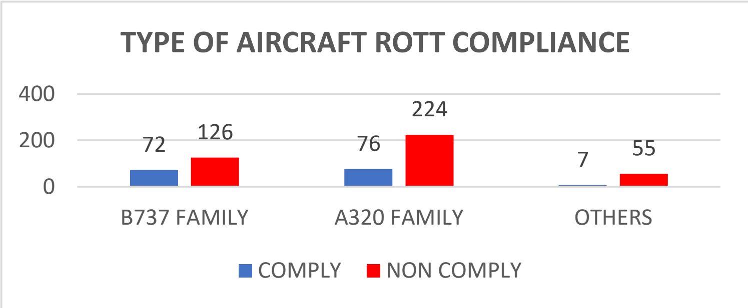

Figure 7. Number of ROTT by Aircraft Type

In summary, from the observed data, the A320 family aircraft had the highest compliance rate with the standard for Runway Occupancy Time Take Off (ROTT), reaching 49%.

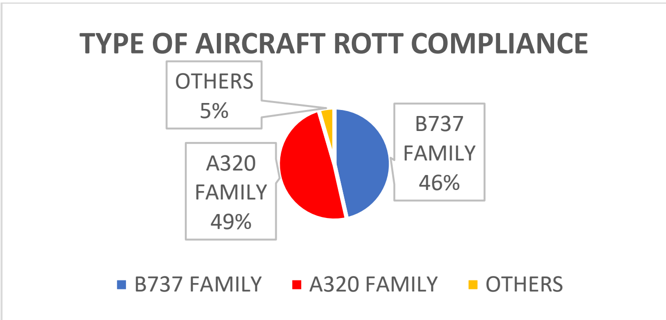

Figure 8. ROTT Compliance Rate by Aircraft Type

2) Runway occupancy landing time (ROTL) compliance level

From the analysis results, it was found that out of the 560 observed arrival aircraft, the most common aircraft types were the A320 family and B737 family. There were 271 aircraft from the A320 family and 224 aircraft from the B737 family. Additionally, 65 other aircraft belonged to different types such as B777, B787, A330, A350, and other jet engine types.

Out of the 271 A320 family aircraft observed for Runway Occupancy Time Landing (ROTL), 151 aircraft met the standard, while 120 aircraft did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

For the B737 family aircraft, out of the 224 observed, 148 aircraft met the standard for Runway Occupancy Time Landing (ROTL), while 76 did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

Regarding other jet engine types, out of the 65 observed aircraft, 28 met the standard for Runway Occupancy Time Landing (ROTL), while 37 did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

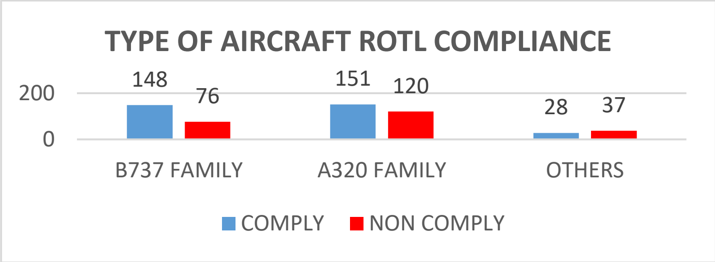

Figure 9. Number of ROTL by Aircraft Type

In summary, from the observed data, the A320 family aircraft had the highest compliance rate with the standard for Runway Occupancy Time Landing (ROTL), reaching 46%.

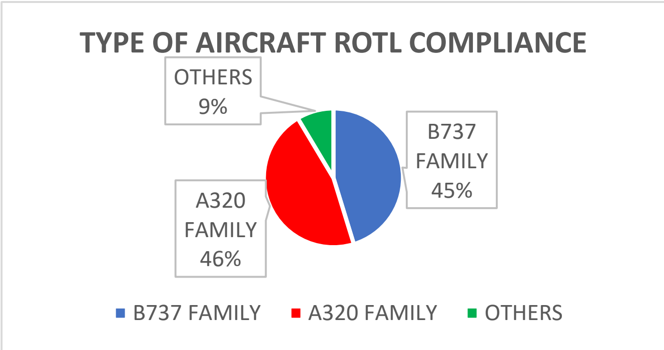

Figure 10. ROTL Compliance Rate by Aircraft Type

c) Analysis of runway occupancy time compliance level based on *airline*

1) Runway occupancy take off time (ROTT) compliance level

Based on the observation results, from the 560 observed departure aircraft, there were 6 (six) airline operators with the highest number of flights during the survey. These airline operators are Batik Air, Garuda Indonesia, Lion Air, Super Air Jet, Citilink, and Air Asia Indonesia.

During the observation for this study, Garuda Indonesia had the highest compliance rate with the standard for Runway Occupancy Time Take Off (ROTT), with 36 aircraft or 23% of the total number of aircraft that met the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

The compliance rate with the standard Runway Occupancy Time Take Off (ROTT) based on airline operators can be seen in the figure below:

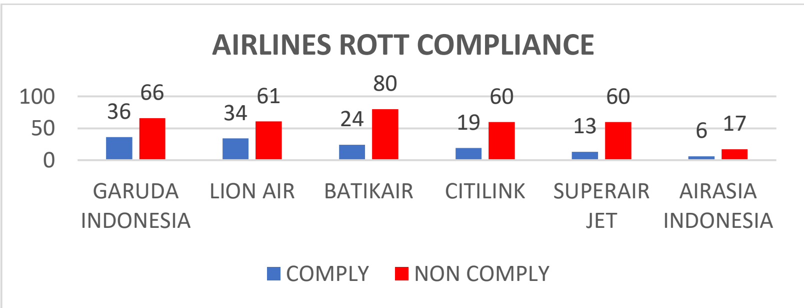

Figure 11. Number of ROTT By airline

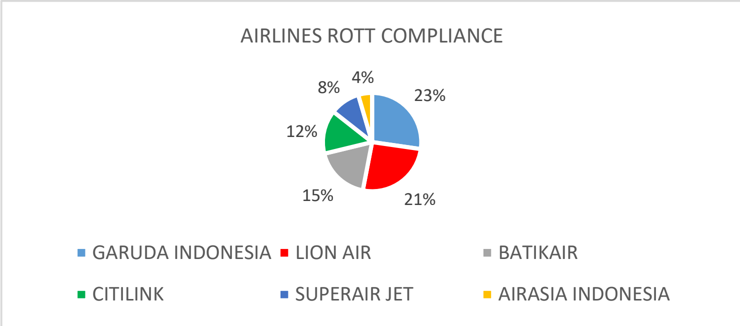

Figure 12. ROTT Compliance Rate Based on airline

2) Runway occupancy landing time (ROTL) compliance level

Based on the observation results, from the 560 observed arrival aircraft, there were 6 (six) airline operators with the highest number of flights during the survey. These airline operators are Batik Air, Garuda Indonesia, Lion Air, Super Air Jet, Citilink, and Air Asia Indonesia.

During the observation for this study, Garuda Indonesia had the highest compliance rate with the standard for Runway Occupancy Time Take Off (ROTT), with 65 aircraft or 21% of the total number of aircraft that met the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

The compliance rate with the standard Runway Occupancy Time Take Off (ROTT) based on airline operators can be seen in the figure below:

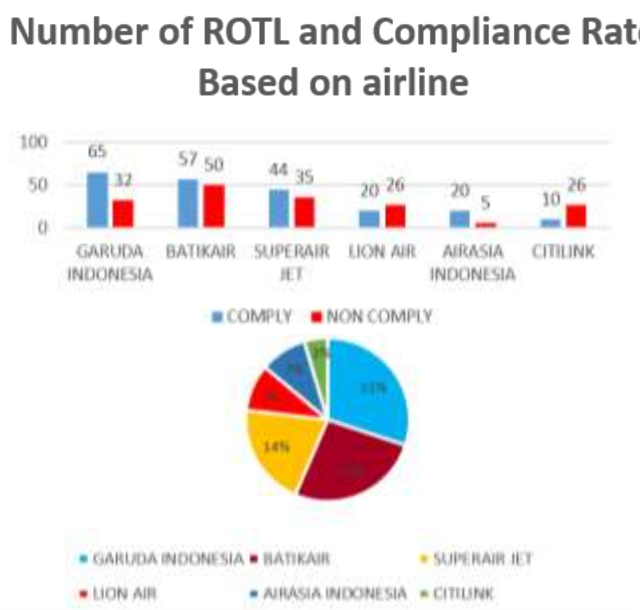

Figure 13. Number of ROTL and Compliance Rate Based on airline

d) Analysis of total runway occupancy time compliance level

1) Runway occupancy take off time (ROTT) compliance level

From the observation results, it was found that out of the total 560 observed departure aircraft, 155 aircraft met the standard for Runway Occupancy Time Take Off (ROTT), while 405 aircraft did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

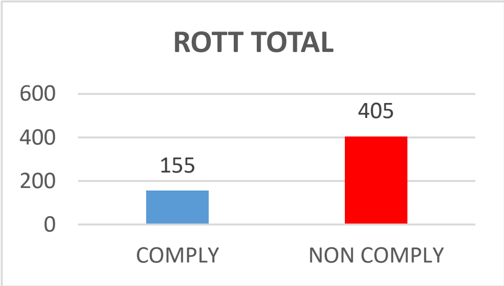

Figure 14. Total ROTT Amount of Flights

In summary, from the observed departure aircraft data, 28% met the standard for Runway Occupancy Time Take Off (ROTT), while 72% did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

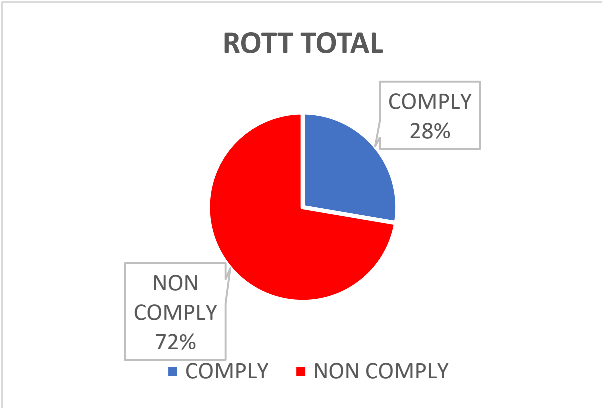

Figure 15. Total Flight ROTT compliance Rate

2) Runway occupancy landing time (ROTL) compliance level

From the observation results, it was found that out of the total 560 observed departure aircraft, 327 aircraft met the standard for Runway Occupancy Time Landing (ROTL), while 233 aircraft did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

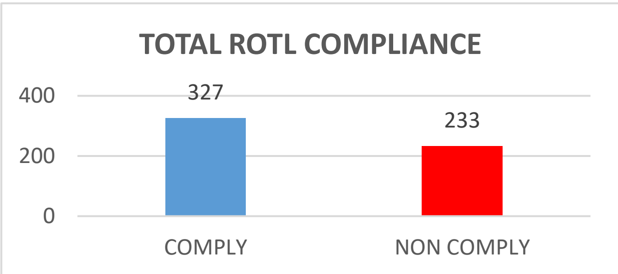

Figure 16. Total ROTL amount of flights

In summary, from the observed departure aircraft data, 58% met the standard for Runway Occupancy Time Landing (ROTL), while 42% did not comply with the standard set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

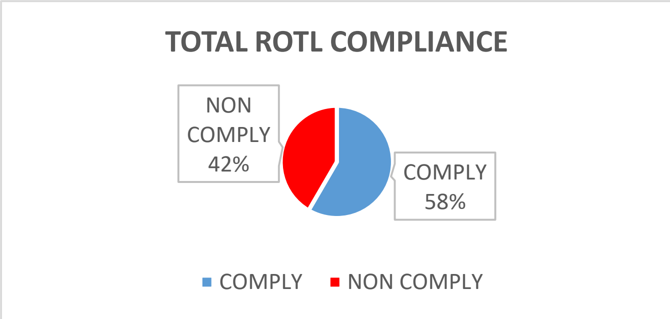

Figure 17. Total flight ROTL compliance rate

e) Analysis of the average ROTT and ROTL values of Soekarno – Hatta Airport

Based on the above analysis of ROTT and ROTL, the researcher calculated the average values for Runway Occupancy Time Take Off (ROTT) and Runway Occupancy Time Landing (ROTL).

The average ROTT value was calculated by dividing the total sum of ROTT values by the number of observed departure aircraft. The calculated average ROTT value for Soekarno-Hatta Airport based on observations is 95.36 seconds. This is 5.36 seconds higher than the standard value for Runway Occupancy Time Take Off set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

On the other hand, the average ROTL value was calculated by dividing the total sum of ROTL values by the number of observed arrival aircraft. The calculated average ROTL value for Soekarno-Hatta Airport based on observations is 54.63 seconds. This is 0.67 seconds less than the standard value for Runway Occupancy Time Landing set in the Aeronautical Information Publication (AIP) Volume II Aerodrome WIII (Soekarno-Hatta).

f) Analysis of factors influencing the non-fulfillment of ROTT and ROTL standards at Soekarno-Hatta Airport

From the observation results of Runway Occupancy Time conducted by the researcher in 14 days on peak hours between June 8th until September 21st 2023, there are several factors influencing aircraft that prevent them from meeting the ROT values as per the established procedures, both during take off and landing at Soekarno-Hatta International Airport. The following are the factors outlined by the researcher:

1) Wake turbulence separation

Wake turbulence separation is a method of spacing between two or more aircraft based on the swirling mass of air generated by the jet engines of an aircraft.

In observation, the researcher found that when an aircraft takes off without a preceding departure, it tends to comply with specified Runway Occupancy Time (ROT) values. However, when an aircraft preparing to take off is preceded by another departure, the second aircraft complies with wake turbulence separation regulations, leading to additional runway occupancy time, extending it by several seconds or even minutes.

2) Pilot response time

Pilot response time, the duration for pilots to adjust to expected or instructed conditions, varies when receiving clearance for take off, as outlined in a FAA journal. The response time depends on the aircraft's performance, with Airbus averaging 9.061 seconds (standard deviation 3.2793 seconds) and Boeing averaging 8.965 seconds (standard deviation 2.4030 seconds). The study concludes that Airbus aircraft provide slightly more time to meet Runway Occupancy Time (ROT) values compared to Boeing aircraft.

3) Distance to vacate runway relate to delaying time when line up (for landing)

During observation, delays were noted when an aircraft preparing for takeoff followed a landing aircraft. After receiving clearance from ATC, the departing aircraft lines up shortly after the landing aircraft passes. The second aircraft then waits for the first to fully exit the runway. The duration of runway usage for the departing aircraft depends on the speed of the recently landed aircraft's exit. Faster exits result in shorter runway usage times for the departing aircraft, and vice versa.

4) Aircraft category relate to aircraft speed for takeoff

From the observation activities, the researcher found that the main factor influencing runway occupancy time is the aircraft category based on speed. The researcher discovered that aircraft in category C has a longer runway occupancy time compared to aircraft in category D.

5) Distance to vacating runway

The distance between the touch down zone and the rapid exit taxiway significantly affects the runway occupancy time during landings. Runway 06/24, with a rapid exit taxiway located approximately 2604 m and 2379 m from the touch down zone, illustrates this impact. In contrast, runways 07R/25L and 07L/25R have exit taxiways closer to the touch down zone at distances of 2210 m and 2325 m, and 2158 m and 2151 m, respectively. The research findings indicate that the majority of aircraft landing on runway 06/24 did not meet the established Runway Occupancy Time (ROT) standards.

6) Aircraft landing distance requirements

Each aircraft type has distinct minimum landing distance requirements, influenced by factors like weight, air temperature, braking systems, and wind speed. Airbus, known for its superior braking features, generally has smaller minimum landing distance requirements than Boeing. However, the effectiveness of an aircraft's braking system doesn't necessarily translate to a shorter Runway Occupancy Time (ROT) during landing at Soekarno-Hatta International Airport. The presence of a preferred exit taxiway, like the nearest rapid exit taxiway, plays a crucial role. Despite Airbus' efficient braking system, the need for more ground rolling to reach the nearest exit may contribute to ROT. In contrast, Boeing aircraft may not require as much ground rolling to access the nearest exit taxiway..

Conclusion

Based on the results of observation and data analysis, as well as the discussion above, the following conclusions can be drawn:

1. The average Runway Occupancy Time during takeoff (ROTT) at Soekarno-Hatta Airport is 95.36 seconds. This is 5.36 seconds longer than the standard Runway Occupancy Time for takeoff specified in the Aeronautical Information Publication.
2. The average Runway Occupancy Time during landing (ROTL) at Soekarno-Hatta Airport is 54.63 seconds. This is 0.67 seconds shorter than the standard Runway Occupancy Time for landing specified in the Aeronautical Information Publication.
3. The compliance rate with the standard Runway Occupancy Time (ROT) at Soekarno-Hatta Airport is as follows:
   a. From the observed departing aircraft data, 28% meet the standard Runway Occupancy Time for takeoff (ROTT), while 72% do not meet the standard ROTT specified in the Aeronautical Information Publication.
   b. Meanwhile, for the observed departing aircraft, 58% meet the standard Runway Occupancy Time for takeoff (ROTT), and 42% do not meet the standard ROTT specified in the Aeronautical Information Publication.
4. The Arithmetical Mean Runway Occupancy Time (AMROT) at Soekarno-Hatta Airport are:
   a. AMROT for Runway 25R is 80.72 for category C and 78.83 for category D.
   b. AMROT for Runway 07L is 80.66 for category C and 78.67 for category D.
   c. AMROT for Runway 25L is 82.37 for category C and 80.78 for category D.

d. AMROT for Runway 07R is 82.53 for category C and 81.29 for category D.

5. With a delay of 5.36 seconds in runway occupancy time take-off, this can lead to a domino effect and flight delays. In this case, the author recommends holding a forum meeting among stakeholders so that aircraft departures can be expedited and not linger too long on the runway.

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