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Research Article

Enhancing Air Travel Analysis: Forecasting Domestic Flight Activities in Indonesia based on Aircraft Types using MLP

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Abstract: The COVID-19 pandemic has succeeded in bringing down various industrial sectors, including the aviation industry. This pandemic impacted the depletion of the operational fleet. In 2022, the number of domestic aircraft ready for operation was only around 55%–60% compared to 2019. However, with all its limitations, the aviation industry must develop the best strategy to revive in this post-pandemic era. One of the strategies undertaken is selecting the most efficient and economical aircraft type to cut costs amid market uncertainty due to this pandemic. In this regard, research was carried out to predict the number of passengers and the dominance of aircraft types in domestic flights in 2023-2024. Multilayer Perceptrons (MLP) show that domestic flight activities in Indonesia will reach the standard point in March 2024. From the forecast of domestic flight activities, the error rate using MAPE is 0.52%. The aircraft that dominates Indonesia's domestic flight activities during 2020–2022 is the Airbus 320 type. Meanwhile, for January 2023 to December 2024 it is predicted that the Airbus 320 type will continue to dominate the flights with the prediction of flight frequency of 916,337.

Keywords: post-pandemic, domestic flight, aircraft types, forecasting, MLP

Introduction

The COVID-19 pandemic has had a detrimental effect on numerous industrial sectors, including the aviation industry. This rapidly spreading disease has compelled governments worldwide to impose restrictions on the movement of their citizens, resulting in a significant impact on the aviation sector in Indonesia. Consequently, several airports have closed specific entry points, and numerous airlines face the imminent risk of closure. In order to mitigate financial constraints, these airlines are compelled to open and close flight routes periodically [1].

Over time, the COVID-19 pandemic in Indonesia is getting better, and 2022 was a critical point where travel restrictions are no longer imposed [2]. In line with the recovery from COVID-19, the aviation industry in Indonesia is also starting to wake up and making various efforts to encourage flight activities to return to normal as before the COVID-19 pandemic occurred. The rise of the aviation industry is evidenced by the recovery rate for aircraft passenger movements in 2022, which has reached 71% for domestic flight aircraft compared to the year before the pandemic in 2019 [2].

To help recover post-pandemic aviation activities, it is crucial to carry out a research related data that can be used as a basis for recovery policies. In [3], the number of airplane passengers in 2022–2024 is predicted to increase significantly by 150%–200% using the ARIMA method. Another study concluded that the intervention method shows that the number of airplane passengers at Soekarno-Hatta Airport will recover in 2021. The forecast has an accuracy using MAPE of 7.79% for train data and 14.07% for test data [4].

Besides the decline in the number of airplane passengers, another issue arising from the COVID-19 pandemic is the reduction in the operating fleet. According to a report by the Ministry of Transportation of the Republic of Indonesia [1], in 2022, the number of domestic aircraft ready for operation was only around 55%–60% compared to 2019. Therefore, airlines have tried to develop strategies for selecting the most efficient and economical aircraft to reduce costs amidst market uncertainties caused by the pandemic.

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In response to this problem, this research aims to forecast the historical data of domestic aviation activities in Indonesia for the past three years (2020–2022). This data will predict when domestic flight activities in Indonesia will return to normal. The transition to a state of normalcy can be officially signaled by the issuance of a government regulation declaring the conclusion of the COVID-19 pandemic status in Indonesia [5]. Nearly all facets of daily life, including the aviation sector, resume their usual operations and activities during this period. Additionally, the dominance of different aircraft types in domestic flight activities over the past three years will be analyzed, and the forecasted flight movements of these aircraft types will be considered for future strategies.

In contrast to previous research on post-pandemic aviation industry activities, this study will utilize the Multilayer Perceptrons (MLP) method, considered more suitable for the data. The MLP model can capture complex nonlinear relationships between input and target variables. This flexibility allows the model to handle various forecasting problems involving intricate patterns and dependencies [6]. Using multiple hidden layers with nonlinear activation functions, the MLP can learn and represent complex relationships in the data, leading to improved forecasting accuracy. Furthermore, the MLP model is highly adaptable and can be applied to various forecasting tasks. It can handle both time series forecasting, where the input variables are historical data points, and multivariate forecasting, where multiple input variables are considered simultaneously [6]. This versatility makes the MLP model suitable for various applications, including weather forecasting, stock market prediction, and energy demand forecasting. The dataset used in this research is relatively small and less than 50 observations, making previous methods unsuitable [7]. Consequently, the approach is the Artificial Neural Network (ANN) machine learning method, widely recognized for its adaptability to changing data [8]. Specifically, the MLP method will be employed, as several studies have demonstrated its superior performance with data containing extreme values [9], [10].

Materials and Methods

Data and Variables

The data used in this research is Aircraft Movement Data for 2020–2022 which contains records of every flight activity. This data is secondary data provided by the Division of Data and Evaluation of Aviation Navigation Services, AirNav Indonesia. There are five variables will be used:

1. Count of DOF/Number of Domestic Flights
   The number of flights variable shows the frequency of aircraft flight activity marked by the flight of the aircraft from the runway to landing. As for this variable, the calculated aircraft flight activity is the sum of every monthly domestic flight activity in Indonesia.
2. Count of DOF/Number of Domestic Flights (Based on Aircraft Type)
   The number of flights variable shows the frequency of aircraft flight activity marked by the flight of the aircraft from the runway to landing. As for this variable, the calculated aircraft flight activity is the number of domestic flight activities for each aircraft type in Indonesia each month.
3. Month
   The month variable indicates the month of a scheduled flight which will later become a reference for calculating the number of flights each month.
4. ADLO
   The ADLO variable is a variable that indicates flight status, which consists of 4 statuses:
   - A: Arrival
   - D: Departure
   - L: Local
   - O: Overflying
5. DOMINT
   The DOMINT variable is a variable that indicates the type of flight based on the flight area. From this variable, the area that will be used is a domestic area which means flights where the departure and arrival points are in the same country, in this case, Indonesia.

Research Methodology

The data preprocessing stage will first be carried out from the data described above number one to three. This stage includes checking the data structure, filtering data, cleaning duplicate data, checking for missing values, and summarizing the data into data on the number of flight activities each month.

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After the data is ready to be analyzed, forecasting is carried out using the MLP method. MLP is one of the popular ANN methods. The perceptron layers combine to form complex multilayer architectures and can increase model specialization by adding layers and neurons. This allows the model to learn complex patterns and increases the ability of the model-to-model different problems [11], [12].

The following is an MLP network architecture or also called feedforward.

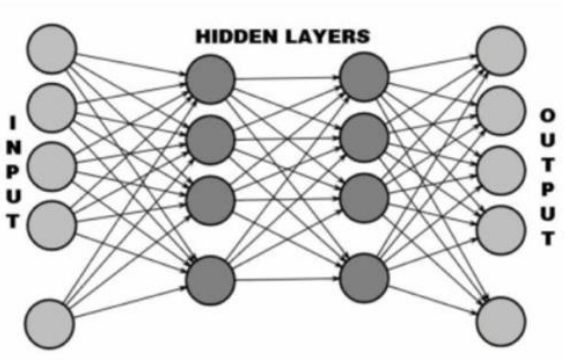

Figure 1. Architecture of MLP [12]

MLP has hidden layers which allow information to be processed sequentially through each layer to produce output. The lines connecting the layers are called synapses. Similar to the linear scenario, we will designate the activations of the input units as x and the activation of the output unit as y. The units in the l-th hidden layer will be labeled as $h_i^{(l)}$. The network is completely interconnected, implying that each unit is linked to all the units in the preceding layer. Consequently, each unit possesses its individual bias, and there exists a weight for every pair of units in two successive layers. Therefore, the computations of the network can be expressed as [13]:

$$h_i^{(1)} = \emptyset^{(1)}\left(\sum_j w_{ij}^{(1)} x_j + b_i^{(1)}\right)$$
$$h_i^{(2)} = \emptyset^{(2)}\left(\sum_j w_{ij}^{(2)} h_j^{(1)} + b_i^{(2)}\right) \quad (1)$$
$$y_i = \emptyset^{(3)}\left(\sum_j w_{ij}^{(3)} h_j^{(2)} + b_i^{(3)}\right)$$

The different symbol between $\emptyset^{(1)}$ and $\emptyset^{(2)}$ because various layers may employ distinct activation functions.

After obtaining the forecasting model, then forecasting the frequency of the number of flight activities is carried out. To determine the accuracy of the forecasting results obtained, an evaluation of these results is carried out using the Mean Absolute Percentage Error (MAPE) value. MAPE is one way to evaluate prediction/forecasting results. If p_i is the forecasting value of the i-th observation, y_i is the i-th observation value, and n is the number of samples, so that the MAPE value is calculated using the following formula [14]:

$$MAPE = \frac{\sum \frac{|p_i - y_i|}{|y_i|}}{n} x100\% \quad (2)$$

According to Lewis [15], the MAPE value can be interpreted in the following categories:

Table 1. MAPE Classification Table

MAPE	Interpretation
< 10 %	Highly accurate forecasting
10% - 20%	Good forecasting
20% - 50%	Reasonable forecasting
> 50%	Inaccurate forecasting

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Result and Discussion

Descriptive Analysis of Domestic Flight Activities in Indonesia

Based on the Flight Movement Data for 2020–2022 that is ready for use, a monthly calculation is made of the number of domestic flight activities. The following is the development of domestic flight activities in 2020–2022.

Figure 2. Graph of Number of Domestic Flight Activities in Indonesia 2020–2022

Based on the line chart in Figure 1. above, from January to May 2020, the movement of domestic flights in Indonesia experienced a very drastic decline, where the numbers started at 155,457 flights and then decreased to 23,795 flights. This significant decrease is the effect of various government policies in limiting the mobilization of Indonesian people during the COVID-19 pandemic.

The strictness of government policies in limiting community mobilization began to be lessened so that from May to December 2020, there was a significant increase. However, it had yet to reach the point in January 2020. As calculated from December 2020, the line continued to fluctuate. Then, in July and August 2021, the decrease reoccurred to its lowest point since December 2020. This decrease occurred due to a surge in cases of the COVID-19 pandemic since the end of June 2021 which required the government to issue a *PPKM Darurat* policy and tighten restrictions on community mobilization again [16].

In line with the decline in COVID-19 cases, transportation in Indonesia particularly airplanes are again pushing for the recovery of its use so that as of August 2021, the movement of domestic flights in Indonesia has slowly begun to increase even though it is still fluctuating. This increase occurred until December 2022 the movement of domestic flights in Indonesia touched 128,567 flights.

Forecasting of Domestic Flight Activities in Indonesia

Based on the historical data above, forecasting is carried out to predict when domestic flights in Indonesia will reach the point where flights are considered back to normal as before the pandemic. The point which indicates that flight movements are returning to normal (baseline) according to the Division of Data and Evaluation of Aviation Navigation Services, AirNav Indonesia is the point in January 2020 where the total flight movement was 155,457.

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Since the data has a very significant decline from January to May 2020 that could affect the forecasting results, the forecast is made from May 2020, when it is slowly recovering from the pandemic. Based on the forecasting performed using the MLP method, the following is the network architecture forecasting model obtained.

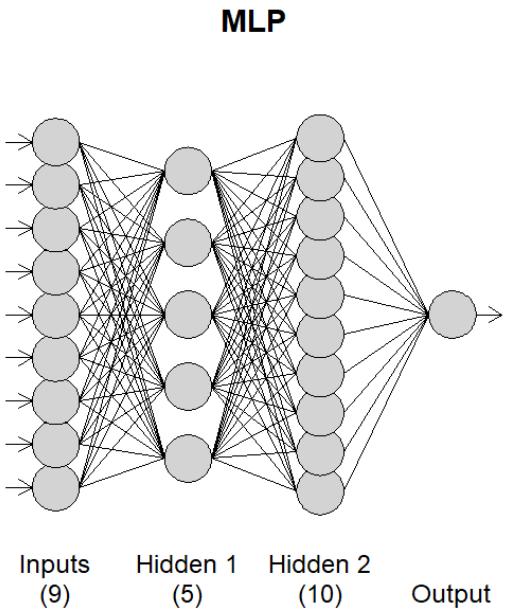

Figure 3. Network Architecture of the Forecasting Model for Domestic Flight Activities

From Figure 3., forecasting has as many as nine neurons input. Furthermore, the first hidden layer has five neurons, so the synapses connecting the input and the first hidden layer are as many as 45. Then, there are ten neurons in the second hidden layer, so the number of synapses connecting the first and second hidden layers is 50. Finally, from the second hidden layer, it produces one output neuron. The model selected some autoregressive lags, in this case, it uses 1, 2, 3, 4, 5, 6, 8, 9, 12 lags as the input node. The model trains 20 networks, which are used to produce an ensemble forecast and two hidden layers with 5 and 10 nodes. As an illustration, if we want to predict the number of aircraft passengers in January 2023, we use the data in January 2022, April 2022, May 2022, July 2022, August 2022, September 2022, October 2022, November 2022, and December 2022.

This architecture obtained the predicted results for domestic flight activities from January 2023 to December 2024. The following is a comparison between actual data, fitted data, and forecast data.

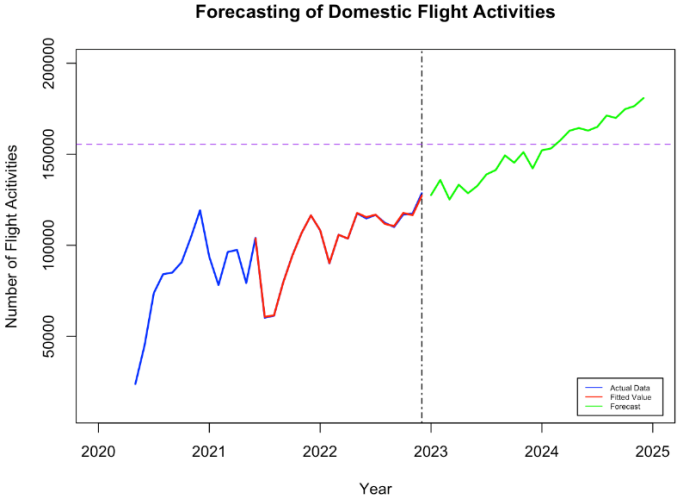

Figure 4. The Plot of Domestic Flight Activities' Forecast

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In Figure 4. the line chart has 3-line colors. The blue line describes the actual data/historical data, the red line is the fitted data, and the green line describes the forecast. Then there are vertical and horizontal straight lines where the vertical line becomes the boundary between the fitted line and the actual data with the forecasting line. Meanwhile, the horizontal line has a y-axis of 155,457, a point in January 2020. This baseline helps to show when flight activity will touch a regular point.

Based on this information, from August 2022, domestic flight activities in Indonesia have started to recover, showing an increasing trend. It is predicted that this will continue until December 2024, reaching 196,557 flights.

With this increase, flight activity is predicted to touch the baseline point as a reference that flight activity has returned to normal in March 2024 with a predicted flight frequency of 157,718. When compared between March 2024 and December 2022, the increase until March 2024 was 22.67%.

Returning to the plot in Figure 4., the fitted line is almost perfectly able to follow the actual data, indicating that the forecast is perfect. The MAPE value obtained from this forecast is 0.52%, meaning that the model obtained using the MLP method is classified as a highly accurate forecasting model.

Descriptive Analysis of Domestic Flight Activities Based on Aircraft Types in Indonesia

After forecasting flight activity in Indonesia and knowing predictions of when flight activity in Indonesia will touch the baseline point and considered normal again, a narrower analysis is carried out on the types of aircraft widely used during 2020–2022.

The following chart illustrates the frequency of flight activities of the ten types of aircraft that dominate Indonesian domestic flights in 2020–2022.

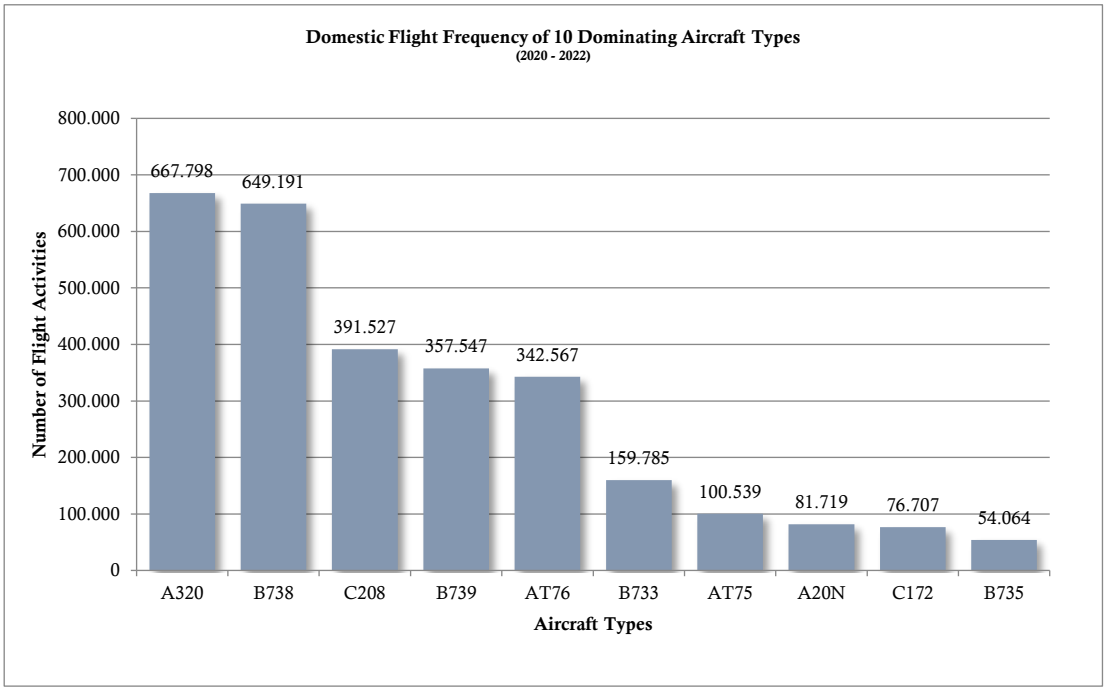

Figure 5. The Plot of Domestic Flight Activities of 10 Dominating Aircraft Types

From Figure 5., during 2020–2022 the aircraft with the highest frequency of domestic flights was the Airbus A320 (A320) type aircraft with a total of 667,798 flights. However, this figure only slightly differs from the Boeing 737-800 (B738) aircraft, with a difference of only 18,607 flights. These two aircraft types have a considerable difference from other types. These two types of narrow-bodied and two-engine aircraft are very popular and sold well in the market.

Then the next rank is occupied by Cessna 208 (C208), Boeing 737-900 (B739), ATR 72-600 (AT76), Boeing 737-300 (B733), ATR 72-500 (AT75), Airbus A320 Neo (A20N), Cessna 172 (C172), and in 10th place is the Boeing 737-500 (B735).

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Forecasting of Domestic Flight Activities in Indonesia Based on Aircraft Types

Forecasting of the ten aircraft types is then carried out using the MLP until December 2024. The following graph shows the actual and forecasting data for the ten aircraft types.

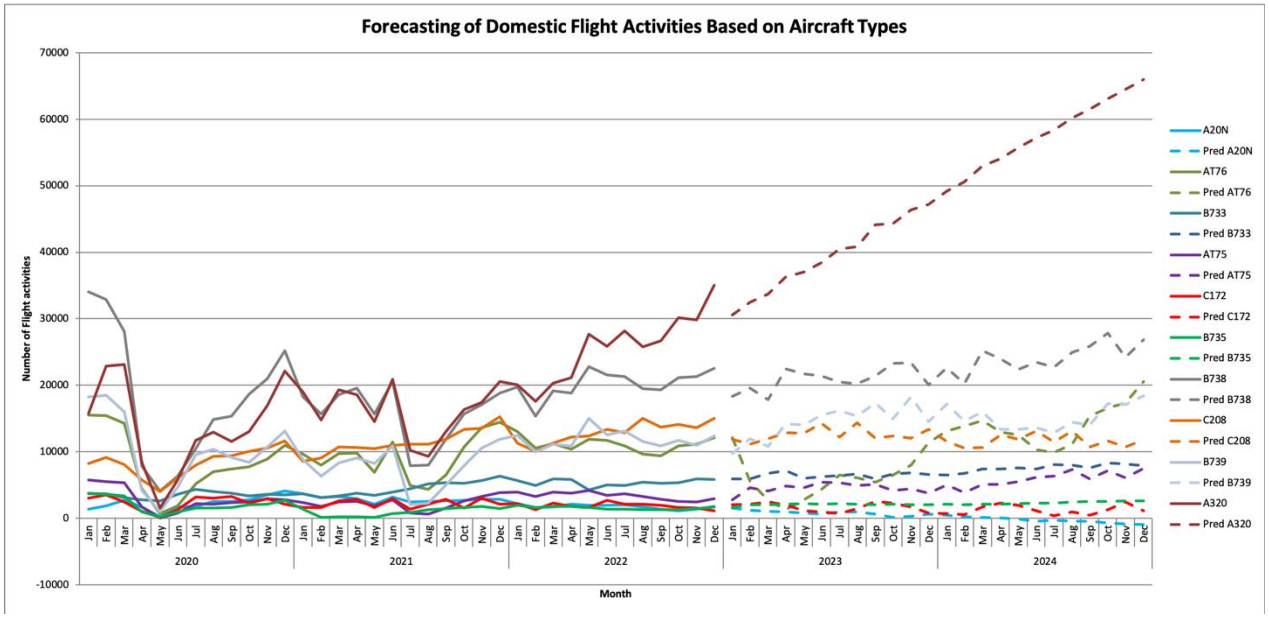

Figure 6. The Plot of Domestic Flight Frequency Based on Aircraft Types

In Figure 6. above, the ten colors represent different aircraft types. The actual data line is solid, and the forecast data is a dashed line.

In actual data, overall, there was a similarity in events in May 2020, where flight activity on all aircraft dropped to less than 5,000 flights. As previously explained, from January to May 2020, the COVID-19 pandemic occurred massively, causing flight activities to be severely restricted and causing this very significant decline.

In July and August 2021, several aircraft types also had the same decline pattern. It occurred because, in July and August 2021, a *PPKM Darurat* was implemented due to increased COVID-19 cases. However, several aircraft types experienced a further decline, including the C208, B733, C172, and B735 types. These four aircraft types are bush or cargo aircraft, so they are not too affected by this emergency *PPKM policy*.

The next highlight that can be highlighted is the dominance of aircraft types from January 2020–December 2024. In January 2020, domestic flight activities were dominated by aircraft with the B738 type. After a massive decline in May 2020, the B738 and A320 aircraft were chasing each other to occupy the highest positions in domestic flight activities. However, starting from the massive decline in July and August 2021, aircraft with the A320 type continue to dominate domestic flight activities in Indonesia and beat the B738 type.

The same dominance is predicted to continue until December 2024, when aircraft with the A320 type will have a higher flight activity frequency than the B738. The gap or difference between the two will continue to widen or increase.

An increasing forecasting trend is seen for all aircraft types except for the A20N and C172 types. The decrease in the C172 aircraft type fluctuated and was not too significant. Meanwhile, on the A20N aircraft type, the decrease that occurs tends to be constant.

After forecasting, the following is a summary of the MAPE value and the percentage increase in December 2024 to December 2022 in forecasting domestic flight activity based on aircraft type using the MLP method.

Table 2. MAPE Summary in Domestic Aircraft Types.

	A20N	**AT76**	**B733**	**AT75**	**C172**
MAPE	0,49%	2,73%	0,39%	8,70%	5,21%
	B735	**B738**	**C208**	**B739**	**A320**
MAPE	9,96%	1,33%	0,53%	3,90%	0,83%

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Table 3. Percentage Increase in Domestic Aircraft Types.

	A20N	AT76	B733	AT75	C172
% Increase	-153,29	70,31	35,93	156,27	-2,17
	B735	**B738**	**C208**	**B739**	**A320**
% Increase	50,73	19,15	-21,33	49,13	88,54

Table 2. shows that the highest accuracy (lowest MAPE) is in the forecasting model for the B733 aircraft type, with a MAPE value of 0.39%. On the other hand, the model with the lowest accuracy is forecasting the B735 aircraft type with a MAPE value of 9.96%. However, forecasting for all aircraft types is still classified as highly accurate because they all are <10%. Meanwhile, based on Table 3, the prediction results show that there will be a decrease in the number of A20N type aircraft passengers in December 2024 compared to December 2022 by 153.29%. On the other hand, it is predicted that there will be an increase of 156.27% in AT75 type aircraft.

After knowing the prediction of the frequency of domestic flight activity for each aircraft type, the following graph shows the prediction of aircraft type domination from January 2023–December 2024.

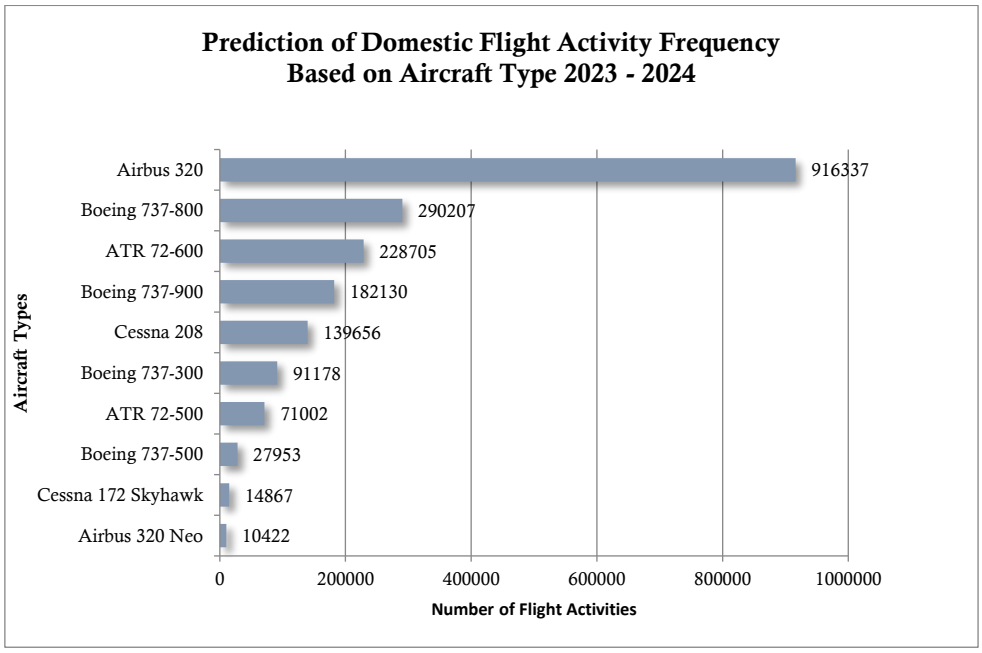

Figure 7. The Plot of Prediction of Domestic Flight Activity Frequency Based on aircraft Type 2023–2024.

If seen and compared between Figure 5. and Figure 7. above, it can be concluded that the Airbus A320 (A320) is predicted to continue to dominate domestic flights in Indonesia for the next two years with a flight frequency of 916,337. However, the difference between the flight frequency of the Airbus 320 and the Boeing 737-800, which was initially small, is predicted to have a large enough gap or difference to around 626,130 flights.

The superiority of the Airbus 320 aircraft compared to the Boeing 737-800 can occur because of several aspects. The Airbus 320 can provide better facilities. Quoted from Simple Flying [17], the A320 aircraft has a larger load capacity with an average passenger of around 185 passengers, while the B737 only has around 160 passengers. In addition, in terms of mileage, the Airbus 320 can provide superior capabilities with a range that can be carried out as far as 3,300 NMI, while the B738 aircraft is only capable of around 2,935 NMI.

Furthermore, there have been several changes in position so that the type of aircraft with the 3rd to 10th highest flight frequency in 2023 – 2024 is ATR 72-600 (AT76), Boeing 737-900 (B739), Cessna 208 (C208), Boeing 737 -300 (B733), ATR 72-500 (AT75), Boeing 737-500 (B735), Cessna 172 Skyhawk (C172), and finally the Airbus 320 Neo (A20N).

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Conclusion

Based on the graph of the frequency of domestic flight activities in 2020–2022, there appears to be a drastic decline until May 2020, which then continued to fluctuate until it only increased steadily again in August 2021. By using the MLP method, it is predicted that all domestic flights in Indonesia will return to normal numbers in March 2024 with a total of 157,718 flights and an increase of 22.67% (compared to December 2022). This forecasting has an error rate/MAPE of 0.52%, which means it is classified as a highly accurate forecasting model. Moreover, the dominant aircraft types both for historical data and two years future predicted are Airbus 320 and Boeing 737–800.

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