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The Implementation of Performance-Based Navigation in Developing Sustainable Business Strategies and Models on Enroute Flight Segment in Indonesia

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Abstract: A new aviation navigation concept has been developed and declared by the International Civil Aviation Organization (ICAO) to increase the level of safety, capacity, efficiency, and sustainability of the world's air transportation system. This concept takes the form of implementing a Communication, Navigation, Surveillance, and Air Traffic Management (CNS-ATM) system with an emphasis on the Performance Based Navigation (PBN) system. This research aims to analyze and examine: (i). The influence of implementing PBN procedures in promoting and fulfilling sustainable air transportation business objectives in order to build aviation navigation infrastructure; (ii). Implementation of aviation navigation regulations in Indonesia that are in line with standards and practices recommended by ICAO; and (iii). Human resource competency development policy (Air Traffic Controller/ATC) that supports the leap from conventional aviation navigation technology to satellite.

This research uses a quantitative research method with the Structural Equation Modeling (SEM) approach and use the statistical application program of Partial Least Square (PLS).

The results of this research found that: (i). There is a positive and significant influence of the Sustainability Dimension variable and the Transportation Objective variable on the Sustainable Business Strategy and Model in the cruise aviation segment in Indonesia; both directly and when using the Performance Based Navigation (PBN) variable as an Intervening variable; (ii). ICAO's initiative on PBN globally was implemented in the form of infrastructure improvements with the creation of the National Air Navigation Plan (NANP) in Indonesia; (iii). In order to optimize PBN routes in Indonesia (through data accuracy, aircraft capabilities, investment, and training in HR aspects), it is the only instrument that can be used to develop HR expertise in implementing PBN.

The implication of this research is that this research can be used as a reference for the Government and leaders of aviation navigation service providers to implement PBN as a policy for developing a reliable and sustainable aviation navigation sector in realizing air connectivity in the Indonesian archipelago.

Keywords: Performance-Based Navigation, Sustainability, Air Connectivity, Public Policy.

Introduction

Transportation has a strategic role in the development of the economy and people's lives from the past until now and in the future, or is said to be sustainable. Developed countries are guaranteed to have reliable and highly capable transportation systems. Likewise, the success of a region's development is supported by the availability of effective and efficient transportation facilities. Transportation facilities consist of infrastructure and modes of transportation. Infrastructure services and modes of transportation form a transportation network. The transportation network consists of an infrastructure network and a service network. The integration of infrastructure networks and transportation facilities will support transportation services. Infrastructure and transportation facilities are very important basic elements in transportation services.

Modes of transportation that have the capacity and are always available cause transportation to change a region so that the emergence of transportation makes a difference in the economic activity of one region to another (Rodrigue et. al., 2006). In air transportation mode, Baker et. al., (2015) provide empirical evidence that the causality running from air transport to economic growth shows that regional aviation has an impact on the local economy in Australia. Likewise, the analysis carried out by Abate et. al., (2020) shows that most governments place a high priority on maintaining air

transport connectivity to protect economic activities and employment within aviation itself, and in related sectors such as the tourism sector. Thus, local economic development strategies must ensure a strong focus on air transport which will then encourage local industries such as tourism.

The air transportation industry is not only a vital engine of global socio-economic growth but is also very important as a catalyst for economic development, creating direct and indirect jobs, supporting tourism and local businesses, and encouraging foreign investment and international trade. According to Lenaerts et. al., (2021), in the last few decades, advances in telecommunications and (air) transportation have driven the globalization process. Therefore, transportation is an important prerequisite for socio-economic development. Broad socio-economic development including sectoral plans and an ecosystem that encourages entrepreneurship is needed to have a strong and sustainable business model (Nicola et. al., 2020).

Space-based aviation navigation provides the opportunity to completely rethink the structure of airspace holistically by taking into account the user's desired route. Indonesia's current air space structure was prepared more than 50 years ago and is generally built based on ground-based technology Navigational Aids and sensing. Airspace boundaries tend to be geo-political and lead to a highly segmented system that can require multiple diversions and many frequency changes within a single flight.

Airspace restructuring is necessary to reflect advances in work methods and technology, a new era of aircraft fleets, new stakeholders in the airspace, and user needs. While local and regional improvements are implemented throughout the process of improving safety and efficiency throughout the air navigation system, airspace modernization initiatives continue to be undertaken with a national holistic view in mind. Airspace modernization is a long-term project that will require careful research, collaboration, testing, and evaluation. Air navigation service providers cannot be alone in this process, there needs to be a government policy, in this case, the Ministry of Transportation, to support this direction and continue to see what is happening throughout the world. Airspace modernization is one of the initiatives that guides air navigation service providers into the future, changing the way they provide services in the long term and providing added value for users.

Achieving a sustainable air transport system has become a well-accepted goal, but how to achieve it remains unclear. The challenges include finding a balance between sustainability dimensions (economic, social, and environmental) and transportation goals (improved mobility, accessibility, and safety), The two often conflict. Various solutions have been proposed to improve sustainability in transportation including technology, policy, operations, taxes, and subsidies or a combination of these. Leuenberger et. al., (2014) attest to specific changes in which sustainability is a useful tool for policy planning and implementation. As noted by Dempsey (2000), in an industry that is connected across borders and increasingly dependent on international operations, international coordination is necessary to improve the sustainability of air transport.

This research aims to find a breakthrough so that there is a balance between the dimensions of sustainability and transportation objectives through the application of performance-based navigation (PBN) so that aviation navigation operators in Indonesia can build sustainable strategies and businesses.

Literature Review

ICAO Standards and Recommended Practices–Performance-Based Navigation

Stakeholders of the world aviation community on April 1, 2009, in Montreal, Canada signed a Declaration calling for the implementation of Performance Based Navigation (PBN). In the ICAO Doc 9613 PBN Manual, PBN is a new aviation navigation concept that will contribute to further improving the safety, capacity, efficiency, and sustainability of the global air transportation system. As ICAO recommends in Doc 9992, PBN helps reduce airport and airspace congestion, increases airspace capacity, saves fuel and protects the environment, reduces the impact of aircraft noise near airports, and ensures reliable all-weather operations. PBN will also give operators greater flexibility while improving security and efficiency. The mission of the ICAO through the implementation of PBN is to provide the safest and most efficient air transportation system possible for world aviation. PBNs are critical to helping fulfill ICAO's mission today and in the future.

PBN sets clear performance requirements for each specific flight operation. This involves a major change from conventional land-based navigation aids and procedures to satellite-based navigation aids and area navigation procedures, which are more accurate and allow shorter and more direct routes between two specific points, as well as more efficient take-offs and landings. This reduces fuel burn, airport and airspace congestion, and aircraft emissions. PBN also improves customer service, by reducing flight diversions caused by low visibility weather conditions and

providing better access to “weather constrained” destination airports, as well as helping to improve overall on-time performance by airlines. The declaration calls on all leaders of the civil aviation community to actively implement PBN in accordance with ICAO requirements. It also reaffirms that global cooperation is critical to the success of such efforts.

PBN is a new operational concept recommended by ICAO based on integrating operational practices and technical standards of Area Navigation (RNAV) and Required Navigation Performance (RNP) in various parts of the World. PBN, combining advanced onboard equipment with satellite-based navigation and other advanced technologies, covers all phases of flight from cruising and terminal areas to approach and landing and enables safer and more accurate flight models as well as more air traffic management models (Air Traffic Efficient Management /ATM).

Implementation of Performance-Based Navigation (PBN) in Indonesia

Information and communication technology is developing rapidly, as is the development of aviation navigation technology. So, in the end, public demand continues to increase. The quality of service to users must be improved. Innovation and smart technology have brought major changes to the world of aviation navigation. Safe and efficient aviation absolutely depends on the effective use of new technology and the management of high-quality aeronautical data. From this point of view aviation really stands out, t is no other sector that relies so heavily on ultra-modern technology to guarantee safety (Fiorentino et. al., 2020). Budd & Budd (2014) suggest that technology is developed and implemented in a sustainable manner to ensure a more environmentally friendly future for aviation.

A key transformation of aviation operations, PBN, can effectively promote sustainable civil aviation safety, increase airspace capacity, reduce investment in ground navigation aids, lower energy consumption and emissions, etc. It serves as one of the core technologies for Indonesia to move from a developing country in aviation quantity to an aviation leader in Southeast Asia and to develop Indonesia's next-generation air transportation system. The Directorate General of Indonesian Civil Aviation (DGCA), decided to speed up the PBN application and regulate comprehensive implementation in accordance with ICAO requirements and Asia/Pacific PBN Implementation Planning. Based on the actual situation in Indonesia, the Government has not yet established a policy and master plan for the DJPU's overall work regarding the implementation of the National Air Navigation Plan (NANP), which can provide guidance to stakeholders and facilitate harmonization of national aviation standards and international cooperation.

Research Methodology

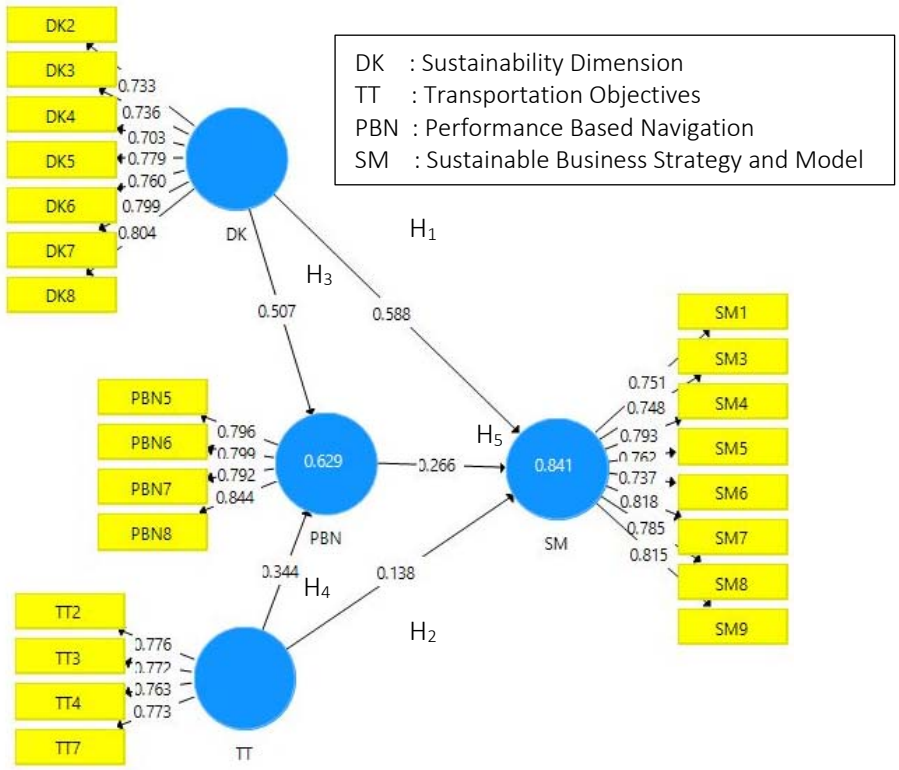
The approach used in this research is a quantitative method with Structural Equation Modeling (SEM) techniques using Partial Least Square (PLS) as a data analysis method. The type and source of data used are primary data collected by researchers to answer problems found in research obtained directly from sources through questionnaires. This data is a collection of data from 257 respondents who are directly related to the implementation of PBN in Indonesia with professions as ATC, Pilot, Flight Inspector, procedure personnel, and PBN Designer.

Results and Discussion

Description of Research Variables

Outer loading value for the Sustainability Dimension, Transportation Objectives, Performance Base Navigation (PBN), and Sustainable Business Strategy and Model variables which have a factor loading value of more than 0.7 is acceptable. There are 10 indicators eliminated in this model, because these indicators have a loading factor value below 0.70. The ten indicators include: DK1, TT1, TT5, TT6, TT8, PBN1, PBN2, PBN3, PBN4, and SM2. After removing invalid variable indicators, the model is then calculated again to produce a new outer loading value, which can be seen in Figure 1.

Figure 1. Path Hypothesis Testing Output Result Diagram Full Sample



Source: Authors

Based on the calculation results to produce a new outer loading value as shown in Figure 1 above, Reliability and Validity Tests were then carried out**.** A construct can be said to be reliable if the Cronbach's alpha value is greater than 0.70, whereas according to Ghozali (2018) a variable is said to be reliable if the composite reliability value is above 0.70. The test results are as shown in Table 1 below.

Table 1. Construct Reliability and Validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Sustainability Dimension	0.878	0.881	0.905	0.578
Performance Based Navigation	0.822	0.826	0.882	0.652
Sustainable Business Strategy and Model	0.906	0.908	0.924	0.603
Transportation Objectives	0.773	0.773	0.854	0.594

Source: Data Processed

Based on Table 1 above, shows that all research variables have composite reliability and Cronbach's alpha values above 0.70. Therefore, the indicators used in this research variable are said to be reliable. Meanwhile, to test validity, use the Average Variance Extracted (AVE) value with a limit value above 0.50. In Table 1, all variables have an AVE value above 0.50. This can be interpreted as meaning that all indicators and variables are declared valid. Furthermore, structural model testing to see the relationship between the constructs, significance values and R-square of the research model. The R-square value can be used to assess the influence of certain independent variables on the dependent variable. The estimated R-square value can be seen in Table 2 below.

Table 2. Coefficient of Determination Value

	R-Square	Adj-R Square
Performance Based Navigation (PBN)	0.629	0.626
Sustainable Business Strategy and Model	0.841	0.839

Source: Data Processed

Based on Table 2 above, is known that the value of R-square for the variable Performance-Based Navigation (PBN) of 0.629, which can be interpreted as the value influence variable Sustainability Dimensions and Transportation Objectives is 62.9% while the rest is explained by other variables outside this research. Meanwhile value of the R-square for the variable Sustainable Business Strategy and Model of 0.841, which can be interpreted as a value influence variable The dimensions of Sustainability and Transportation Objectives is 84.1% while the rest is explained by other variables outside this research.

Hypothesis test

Based on test results using the Bootstrapping function in SmartPLS 3.0, the hypothesis is accepted when the resulting beta value (coefficient) has a positive sign and when the significance level is smaller than 0.05 (alpha 5%) or the t-value exceeds the critical value (1, 96) (Hair et. al., 2014). Direct hypothesis testing in this research was carried out for the 5 proposed hypotheses where the processing results are shown in Table 3 below.

Table 3. Direct Effect Test Results

			Estimate	STDEV	Tstat	P-value	Decision
Sustainability Dimension	→	Sustainable Business Strategy and Model	0.588	0.054	10,923	0,000	Accepted
Transportation Objectives	→	Sustainable Business Strategy and Model	0.138	0.045	3,041	0.001	Accepted
Sustainability Dimension	→	Performance Based Navigation	0.507	0.073	6,907	0,000	Accepted
Transportation Objectives	→	Performance Based Navigation	0.344	0.079	4,342	0,000	Accepted
Performance Based Navigation	→	Sustainable Business Strategy and Model	0.266	0.044	6.116	0,000	Accepted

Source: Data Processed

Based on Table 3 above, the influence between variables can be seen with the following interpretation:

H_1 = There is a significant influence of the Sustainability Dimension on Sustainable Business Strategy and Models.

From the processing results, an estimated coefficient of 0.588 is obtained, which means that increasing the perception of the sustainability dimension will increase sustainable strategies and business models and conversely, decreasing the sustainability dimension will reduce sustainable strategies and business models. The p-value of the t-statistic is $0.000 < 0.05$, indicating that Ha is accepted so that the hypothesis states that the sustainability dimension has a positive effect on sustainable business strategies and models. The results of this study are in accordance with research by Schlenker & Walker (2015) in California, United States, which found that there were quite large morbidity benefits from lowering Carbon Monoxide (CO) standards produced from aircraft engine emissions which had a significant influence on the health of local residents around the airport. so that it influences the determination of sustainable business strategies and models.

Likewise, Lakshmanan (2011) in his research on the contribution of transportation infrastructure to the broader economy found that the dimensions of sustainability in economic terms greatly influence sustainable business

strategies and models. On the other hand, Materna (2019) in his research on several business models of aviation navigation providers found that creating value for their customers has a significant effect on sustainable business strategies and models. Emissions from aviation will continue to increase in the future, contrary to global climate policy objectives. Peeters et. al., (2016) provide evidence that technology can make a significant contribution to climate change mitigation in aviation.

Realizing people's economic aspirations without violating environmental restrictions is important in the twenty-first century. This requires a balance between the economy, society, and the environment using a 'sustainability' paradigm. There is widespread support for this concept and widespread acceptance that sustainability is essential to ensuring the future. Incorporating sustainability into policies and practices is a necessity.

H_2 = There is a significant influence of Transportation Objectives on Sustainable Business Strategies and Models.

From the processing results, an estimated coefficient of 0.138 is obtained, which means that increasing the perception of transportation goals will increase sustainable business strategies and models and conversely, decreasing transportation goals will reduce sustainable business strategies and models. The p-value of the t-statistic is $0.001 < 0.05$, indicating that Ha is accepted so that the hypothesis states that transportation goals have a positive effect on sustainable business strategies and models. The results of this research are in accordance with Bartle's (2006) research in the United States which found that mobility goals and travel acceleration have a significant influence on air transportation practices in meeting sustainable goals and have a major impact on sustainable business strategies and models.

This is in line with the research results of Tuntev & Mehmedi (2019), by implementing RNP AR APCH at Skopje International Airport – North Macedonia in addition to increasing airport accessibility due to reduced decision height and Proper lateral guidance during missed approaches will provide many other benefits such as safety and efficiency operation. These improvements provide an example of how public administrators are answering the call to create solutions that will promote more sustainable transportation. Research by Lutte and Bartle (2017) states that operational improvements are an advantage for the industry in carrying out corporate responsibility and benefits for the environment. The result is an important example of finding a balance between these two often conflicting goals.

Strategies for achieving sustainable development goals that provide flexible implementation plans can produce solutions that can be implemented by system users. In a field that has as many challenges to sustainability as air transport, this is especially urgent and essential.

H_3 = There is a significant influence of the Sustainability Dimension on Performance Based Navigation (PBN).

Based on the processed results, an estimated coefficient of 0.507 is obtained, which means that increasing the perception of the sustainability dimension will increase performance-based navigation and conversely decreasing the sustainability dimension will reduce performance-based navigation. With a statistical t value of 6.907, a p-value of $0.000 < 0.05$ is obtained, which means Ha is accepted so it can be concluded that the hypothesis which states that the sustainability dimension has a positive effect on performance-based navigation is proven.

These results are in accordance with research by Lutte & Bartle (2017), as well as McManners (2015) which also proves that fundamental changes to the policy formulation process are needed if sustainability is to fulfill its potential to reconcile environmental and economic goals that have a positive influence on performance-based navigation. Likewise, research conducted by Fiorentino et. al., (2020), Budd and Budd (2014), and Fitzgerald & Ahmad (2016) which prove that the sustainability dimension influences performance-based navigation. The results of this test prove that the sustainability dimension is a determining variable that influences performance-based navigation, so that the sustainability policy implemented by flight navigation service providers is a policy that provides a win-win solution for society and the future of aviation.

Improving the efficiency and sustainability of air transportation systems so that they are commensurate with the cost and effort of implementation can achieve sustainable development goals providing flexible implementation plans can produce workable and customized solutions that can be implemented by system users.

H_4 = There is a significant influence of Transportation Destination on Performance Based Navigation (PBN).

The processing results obtained an estimated coefficient value of 0.344, which means that increasing transportation destinations will increase performance-based navigation and conversely decreasing transportation destinations will reduce performance-based navigation. The p-value of the t statistic is $0.000 < 0.05$, indicating that Ha is accepted so

that the hypothesis which states that transportation destinations have a positive effect on performance-based navigation is proven. This is in accordance with research by Wong (2018) in his research on aviation connectivity in the United States which found that flight connectivity was a mediating variable between transportation destinations and performance-based navigation and there was a significant relationship between transportation destinations and performance-based navigation.

Tian et. al., (2015) introduced a computational model of airspace conflict risk in the PBN airspace operations hierarchy and combined it with ATC workload, the computational results show that, the greater the airspace conflict risk value, the higher the ATC workload, and the higher poor air space security. In operational planning, aviation safety can be improved by adopting strategies such as changing safety separations, reducing air traffic flow and dynamic sector. Another research is from Timar et. al., (2013), found that RNAV SID and STARs showed increased throughput compared to baseline SID and STARs in every case of inefficiency.

H_5 = There is a significant influence of Performance Based Navigation (PBN) on Sustainable Business Strategy and Models.

From the processing results, an estimated coefficient of 0 is obtained. 266 which means that increasing the application of performance-based navigation procedures will improve sustainable business strategies and models and conversely decreasing the application of performance-based navigation procedures will reduce sustainable business strategies and models. The p-value of the t-statistic is 0.000 < 0.05 shows that Ha is accepted so that the hypothesis states that the implementation of performance-based navigation procedures has a positive effect on sustainable business strategies and models. The results of this study are in accordance with research by Lopez-Lago et al., (2019) found that Performance-based navigation can mitigate risks in airspace which has a significant influence on sustainable business strategies and models.

The results of testing the indirect influence of sustainability dimension variables and transportation objectives on sustainable business strategies and models can be seen in Table 4 below.

Table 4. Indirect Effect Test Results

	Theoretical Hypothesis	Estimate	Tstat	P-value	Results and Conclusions
H_6	There is a significant influence of the Sustainability Dimension on Sustainable Business Strategies and Models through Performance Based Navigation (PBN)	0.135	4.519	0.000	Accepted
H_7	There is a significant influence of Transportation Goals on Sustainable Business Strategies and Models through Performance Based Navigation (PBN)	0.092	3.396	0.000	Accepted

Source: Data Processed

Hypothesis 6 was carried out with the aim of testing the significant influence of the Sustainability Dimension on Sustainable Business Strategy and Models which is mediated through the application of Performance Based Navigation (PBN) procedures. The processing results are shown by an estimated coefficient value of 0.135, which means that increasing the perception of the sustainability dimension will improve sustainable business strategies and models mediated by performance-based navigation procedures and vice versa. The p-value of the t-statistic is 0.000 < 0.05, indicating that Ha is accepted, so it can be concluded that it is proven that the perception of the sustainability dimension has a positive effect on sustainable business strategies and models mediated by performance-based navigation.

Hypothesis 7 was carried out with the aim of testing the significant influence of Transportation Objectives on Sustainable Business Strategies and Models which is mediated through the application of Performance Based Navigation (PBN) procedures. The processing results are shown by an estimated coefficient value of 0.092, which means that increasing the perception of transportation goals will improve sustainable business strategies and models mediated by performance-based navigation procedures and vice versa. The p-value of the t-statistic is 0.000 < 0.05,

indicating that Ha is accepted, so it can be concluded that it is proven that perceptions of transportation destinations have a positive effect on sustainable business strategies and models mediated by performance-based navigation.

Conclusion and Recommendations

Conclusion

Based on the results and analysis previously described, several conclusion points can be drawn related to this research, as follows: (i) The Sustainability Dimension has a positive and significant influence on the Sustainability Strategy and Business Model: The most dominant sustainability dimension is the indicator of the need to develop actionable strategies that incorporate sustainability into the organization's mission and strategic plans; (ii) Transportation Goals have a positive and significant influence on Sustainability Strategy and Business Models: Mobility goals and travel acceleration have a significant influence on air transportation practices in meeting sustainable goals. Their impact has a big influence on sustainable business strategies and models. Safety assessment methods enable effective quantification of safety in relation to airspace operational planning strategies, and benefit the development of optimal operational schemes that balance risks with capacity demands; (iii) The Sustainability Dimension has a positive and significant influence on performance-based navigation (PBN): Fundamental changes to the policy formulation process are needed if sustainability is to fulfill its potential to reconcile environmental and economic objectives that have a positive influence on performance-based navigation. The Sustainability Dimension is a determining variable that influences performance-based navigation so that the sustainability policy implemented by flight navigation service providers is a policy that provides a win-win solution for society and the future; (iv) Transportation destinations have a positive and significant influence on performance-based navigation (PBN): Flight connectivity is a mediating variable between transportation destinations and performance-based navigation and there is a significant relationship between transportation destinations and performance-based navigation: and (v). Performance-based navigation (PBN) has a positive and significant influence on Sustainability Strategy and Business Models. Performance-based navigation can mitigate risks in airspace which has a significant influence on sustainable business strategies and models. The research results concluded that the PBN procedure is recommended to be implemented as a policy for developing a reliable and sustainable aviation navigation sector as air connectivity in the Indonesian archipelago.

Policy Recommendations

Based on the results of this research, there are several policy recommendations, including:

1. Optimal PBN implementation is able to produce several benefits from sustainability aspects (social, economic, environmental), as well as transportation goals (mobility, accessibility, safety) or what can be called a balancing effect. In realizing environmentally friendly aviation and creating a reduction in air emissions, it is best to implement the ICAO policy known as "Carbon Neutral Growth", namely growth without an increase in CO_2 emissions. For example, ICAO targets Carbon Neutral Growth (CNG) starting in 2020, meaning that from 2020 onwards growth in aviation activities must not increase CO_2 emissions, so CO_2 emission levels remain the same as in 2020. One way is to carry out carbon offsets through the Carbon Offset Reduction Scheme for International Aviation (CORSIA) scheme or through the implementation of Performance Based Navigation (PBN) which can regulate flights to be more efficient, because if the route is efficient then the fuel burned will also be reduced and will reduce CO_2 emissions.
2. Policies related to aviation navigation from aviation regulators, in this case, the Ministry of Transportation, should be in line with regional and global initiative plans recommended by ICAO. The implication is that policies related to aviation navigation should be regulated in Government Regulations or Presidential Regulations so that it is hoped that military agencies and other government agencies whose activities are related to civil aviation are in accordance with the regional and global goals of seamless Air Traffic Management (ATM).
3. Indonesia Modernization of Air Navigation Services (IMANS) is a continuous transformation of technology and air traffic control procedures in Indonesia that should be included in the draft national air navigation master plan (National Air Navigational Plan / NANP). The two main components of IMANS are Performance Based Navigation (PBN) and Airspace Optimization. Implementation of Air Traffic Flow Management (ATFM) and Airport Collaborative Decision Making (A-CDM) involving components from airlines, ground handling operators, BMKG and also the military is very important to optimize air space and airport capacity for more effective flight operations. and efficient in Indonesia.

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