Aircraft Selection for Cargo Purposes in Air Charter Company Using the Fuzzy AHP – TOPSIS Method

Luhur Prakoso Prabowo and Teuku Yuri M. Zagloel
Department of Industrial Engineering, Faculty of Engineering
University of Indonesia (UI)
Jakarta, Indonesia
luhur.prakoso@ui.ac.id, yuri@ie.ui.ac.id

Abstract

Transportation by airplane is one of the best options because it provides a faster travel time when compared to other modes. This provides benefits but also risks because this business requires a significant investment. To be profitable in the aviation business, fleet planning must be carried out carefully using an appropriate methodological approach and an important part of the process of planning is the selection of aircraft. Business can gain a competitive advantage by choosing the appropriate aircraft. This study aims to assist decision makers in selecting aircraft for the charter business for cargo purposes by using the right criteria and methods. Multiple Criteria Decision-Making (MCDM) methods are used as a decision-making aid, as in this study, that utilizes the Fuzzy Analytic Hierarchy Process (FAHP) combined with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).FAHP is used because it deals with the ambiguity that comes with decision-making and TOPSIS that maximizes the benefit criteria while offering the solution that minimizes the cost criteria. This article focuses on the topic of decision support for aircraft selection. This is a problem that an air charter company in Indonesia is facing as it invests in chartering aircraft for cargo purposes. The problem has 3 alternatives to be considered that must be evaluated using 3 main criteria: aircraft specifications, financial and added value indicators, and 10 sub-criteria. A systematic literature review was carried out to identify the criteria considered in aircraft selection especially in the cargo-oriented air charter business, as well as to identify research gaps within articles relevant to aircraft selection. Three experts who participated in this study identified the appropriate criteria, resulting in 10 out of 45 sub-criteria. Reliability tests were also performed with positive results. FAHP was used to obtain the weights of criteria and through TOPSIS the alternatives aircraft were evaluated. Previous research has focused on the selection of aircraft for the scheduled flight business of transporting passengers (airlines), despite the fact that there are some fundamental differences between airlines and charter businesses. Findings in this study showed sub-criteria in the selection of aircraft for airlines such as Cost per Available Seat Miles (CASM) and Comfort were not considered in the selection of aircraft for cargo charter. This study contributes to help practitioners in selecting aircraft for cargo charter operations business, as well as academics in providing research in aircraft selection.

Keywords
Aircraft selection, Fuzzy AHP, TOPSIS, Air Charter and MCDM.

1. Introduction
One of the most significant factors that determine airline success is bringing supply and demand as together as possible in the measure of market circumstances and economic environment. Moreover, airlines should make a profit while keeping their clients satisfied and costs to a minimum. Airlines require a suitable methodological approach for the fleet planning process, corresponding fleet selection, and stable fleet management in order to achieve their mission in the market most efficaciously (Dožić and Kalić, 2018).The existence of different aircraft types, each with specific missions and purposes and capable of operating in markets with varying demands and characteristics, will reveal the complexities of the aircraft type selection problem (Kiracı and Akan, 2020). Aircraft selection methods have now become critical in order to gain a competitive advantage in the airline industry, not only for the benefit of passenger flights but also charter flights for cargo purposes, which are growing at a rapid pace. It is critical that airlines choose between aircraft alternatives in order to select the most suitable aircraft. Airlines should choose the most suitable option among the numerous aircraft alternatives. While there are many criteria that must be considered in order to make the most appropriate decisions. Planners can use multiple criteria decision-making (MCDM) methods as a decision-making aid to provide a satisfactory choice while dealing with multiple criteria.

Many methods are used in the evaluation process, and multi-criteria decision-making (MCDM) methods have provided airlines with satisfactory solutions for aircraft selection. Previous studies have also most discussed aircraft selection for scheduled airlines (passenger-based) and for selecting military aircraft, but there is still far too little research that focuses on air charters with a business model for supplying aircraft for cargo purposes, and therefore this research is expected to fill that gap. Even though the characteristics of the cargo charter aircraft business are undoubtedly different from those of the passenger aircraft business, this will have an impact on the criteria used as a reference in making the selection. The model presented here uses integrated methods of Fuzzy Analytics Hierarchy Process (Fuzzy AHP) and Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) and their applicability is illustrated through a case study. The proposed model for aircraft selection allows companies to evaluate the aircraft in terms of specific criteria and, as a result, it helps decision-makers select appropriate aircraft.

1.1 Objectives

- Obtain the appropriate criteria to be applied to the selection of aircraft for charter cargo purposes.
- Knowing the criteria that most influence the selection of aircraft for charter cargo purposes.
- Get the best alternative from several choices of aircraft.

2. Literature Review

Even if it is a personal decision involving a personal issue, decision-making is a mechanism that occurs within a framework. Each decision-making process occurs within a context. The framework within which the decision-making process occurs is made up of various components or items, each of which is a factor that determines everything that does or will happen. The problem that must be solved is the most important factor in the decision-making process. Because all human decisions are always personal, each decision-maker must understand or practice decision-making principles as well as be familiar with the system of everyday human life when it comes to making decisions and adapting to society and the environment. The decision marks the end of the process of considering what is considered a problem and selecting an alternative solution (Atmosudirdjo, 1987).Decision Making refers to the selection of an action from a set of alternatives. Planners in the aviation industry are constantly confronted with new decision-making challenges. A few decisions are not difficult to make, while others involve a variety of options and objectives. Multi Criteria Decision Making refers to the process of selecting an action from a large number of options while taking into account various criteria that influence the judgment to an equal or diverse degree. The options are sorted according to the variables that influence the outcomes. Decision makers employ the Multi-Criteria Decision Making (MCDM) method to assist them in making better decisions (Dožić and Kalić, 2018).MCDM is a process that employs several criteria as a foundation for decision making, with the primary goal of implementing methodology that includes design problems and mathematical techniques for optimization in order to obtain the best solution for the decision makers. In MCDM problems, the performance of the alternatives is evaluated against various and contradictory requirements, and the objectives are merged according to the decision maker's expectations (Hwang and Yoon, 1981).The aircraft selection process is a component of fleet planning. The literature discusses aircraft selection in a variety of ways. From the defined set of aircraft, the aircraft type that best meets the market conditions and the airline's requirements should be selected. Using the MCDM technique is one possible solution to the problem. The Elimination and Choice Expressing Reality (ELECTRE) approach, Simple Additive Weighting (SAW) and TOPSIS and the addition of the Taguchi loss function are proposed to be able to produce a robust/uncertainty-resistant election analysis (Sun, et.al., 2011).Selection of military aircraft and developing models with the TOPSIS approach and Preference Analysis for Reference Ideal Solution (PARIS) to evaluate different aircraft alternatives and support efficient decisions (Ardil, 2020).Given the inherent multi-criteria decision-making problem, the Analytic Hierarchy Process (AHP) is used to select an appropriate aircraft type.AHP is used as an approach in the model for the process of selecting aircraft with a known route network and forecasting air travel demand (Dožić and Kalić, 2014).AHP has been used successfully in areas such as selecting one alternative from many, resource allocation, and forecasting. Because aircraft selection is inextricably linked to these areas, the use of AHP is justified. The benefit of this decision support tool is that the final ranking is based on pairwise relative evaluations of both the criteria and the user's options. Furthermore, the AHP approach is used because its logic is rational and understandable, and the computation process is relatively simple.However, AHP involves human subjectivity, which creates ambiguity and necessitates the use of decision-making under those flaws ((Radionovs & Uzhga-Rebrov, 2017). FAHP is not superior to AHP; the difference between the two methods is in the conditions under which they are used. The AHP approach was used in an aircraft selection process, where the calculation used data and experts from their own airline (Dozic and Kalic, 2014). Several years later, the same researcher used the Fuzzy AHP approach, but this time he included the passenger perspective as well as the airline. Even though the goal of AHP is to capture expert knowledge, traditional AHP cannot reflect ambiguity in human thinking style. As a result, the Fuzzy Analytic Hierarchy Process (Fuzzy AHP), which employs the fuzzy set theory introduced by Zadeh (1965), was developed. TOPSIS method has been widely accepted for aircraft selection due to its simplicity and applicability as well as its high sensitivity in evaluating alternative rankings. Fuzzy AHP – TOPSIS integration model was successfully used in decision making to choose military aircraft, to make a final decision, the Fuzzy AHP method was used to determine the relative weights of multiple evaluation criteria and to synthesize the classifications of candidate aircraft, and TOPSIS was used to obtain a crisp overall performance value for each alternative (Wang, et. al., 2008).This method was also used to select military training aircraft for the Spanish Air Force, using a hybrid modeling approach comprised of Fuzzy AHP – TOPSIS (Sánchez-Lozano, et. al., 2015).

3. Methods

Because the relative importance of criteria cannot always be expressed precisely, and decision makers must often deal with ambiguity, we discovered a way to use fuzzy numbers in the AHP method, i.e., to apply Fuzzy Analytic Hierarchy Process (Fuzzy AHP).Because Fuzzy AHP employs fuzzy set theory, the scale used to weight the factor and the criteria differ from those used in classical AHP. FAHP triangular fuzzy number (TFN) is preferred for pairwise comparison because FAHP scale consists of lower, middle, and upper values, whereas classical AHP has one crisp value for each definition (Table 1).

Table 1. Triangular Fuzzy Scale

Saaty Scale	Definition	TFN		
		l	m	u
1	Equally importance	1	1	1
2	Intermediate values between two adjacent judgement	1	2	3
3	Moderate importance	2	3	4
4	Intermediate values between two adjacent judgement	3	4	5
5	Essential or strong importance	4	5	6
6	Intermediate values between two adjacent judgement	5	6	7
7	Demonstrated importance	6	7	8
8	Intermediate values between two adjacent judgement	7	8	9
9	Extreme importance	9	9	9

Source: Chang (2016)

The steps in using fuzzy AHP can be displayed as follows:

1 Formulate the problem and create a hierarchical structure.
2 Include a pairwise comparison matrix assessment between criteria and sub-criteria with the AHP scale by experts.
3 Changing the pairwise comparison matrix assessment between criteria and sub-criteria given by experts using the AHP scale into the triangular fuzzy number form.
4 Unify pair comparison judgments, if there are more than 2 decision makers.
5 Calculating the fuzzy synthetic extent value of each matrix.

TOPSIS applies the premise that the chosen alternative must be closest to the positive ideal solution and furthest from the negative ideal solution from a geometric point of view. TOPSIS has been widely used to rank options according to unique variables that measure their proximity to the virtual best option and their distance to the virtual worst option.

The positive-ideal solution represents the virtual best option which will be compiled by selecting the best performance for each parameter among the actual proposals; the ideal-negative solution represents the virtual worst option which will be compiled by selecting the worst performance for each parameter among the actual proposals.

TOPSIS step and calculation summarized as shown:

1 Normalized weighted matrix.
2 The positive-ideal solution (A^+) and negative-ideal solution (A^-) are calculated based on benefit criteria (J^+) and costs criteria (J^-)
3 Separation of each choice from the positive-ideal (S_i^+) and negative-ideal values (S_i^-)
4 Calculate the relative proximity of each alternative to a theoretical optimal answer:
$$R_i = \frac{S_i^-}{S_i^- + S_i^+}$$
5 A proportional value is assigned to each choice in respect to the real best answer.
$$V_i = \frac{R_i}{\max(R_i)}$$

4. Data Collection

The company where the research was conducted as a case study is a company providing aircraft charter services for cargo needs based in Indonesia. In this study, three experts each came from different departmental and expertise backgrounds with more than 17 years of experience who were decision makers in the selection of aircraft to become respondents in filling out three questionnaires given by researchers, namely questionnaire I to select criteria. which is used in the selection of aircraft for cargo purposes that are tailored to consumer needs, namely with a minimum payload of 8 tons. questionnaire II to perform pair wise comparison and questionnaire III to choose the best alternative from the three aircraft options, namely ATR 72-600, ATR 72-500 and Dash 8 Q400.

Table 2. Expert as decision makers in this research

Expert No	Position	Department	Experience
EXP-1	VP Business Development & Strategy	Business Development	26 yr
EXP-2	Supply Chain Manager	SCM	18 yr
EXP-3	Operation Director	Operation & Maintenance	27 yr

In the process of selecting criteria, previously the experts agreed on the weight of each expert to show how much influence their decision had, expressed in the following percentages: EXP-1 as the most influential with a weight of 50% and the other two experts namely EXP-2 and EXP- 3 equal 25% each. The biggest decision is from the business development department because it is the one dealing directly with clients and is considered to understand the needs of clients and business the most of the 45 criteria from previous studies that were selected by experts using a questionnaire I with a Likert point scale of 4 (1-4). The Likert scale introduced by Rensis Likert, a psychologist in 1932, is a scale used to measure attitudes, opinions, and perceptions of a person or group of people about a symptom or phenomenon. It is also a psychometric scale that is commonly used in questionnaires, and is a scale used most widely used in research in the form of surveys (Table 2).

The 4-point Likert scale chosen to be used in the questionnaire I of this study is basically a "forced" Likert scale. The reason it's named that way is because users are forced to form opinions. There can be no safe 'neutral' option. Ideally a good scale for validation uses a 4-point scale to get specific responses.After the identification has been completed, then the criteria and sub-criteria are validated. The aim is to evaluate and eliminate the possibility of using criteria and sub-criteria.Questionnaire I resulted in the selection of 10 criteria selected by experts and according to them were the most suitable criteria as criteria for selecting aircraft for cargo charter purposes, these criteria can be seen in Table 3.

Table 3. Selected criteria

Criteria	Description
MTOW	The heaviest weight that authorized to lift flight without exceeding structural or other limitations and the primary method for determining airport and navigational fees (measured in kg).

Payload	The maximum certificated take-off weight of an aircraft less the empty weight (measured in kg).
Range	A farthest a plane may travel in a straight line without refuelling and returning to a starting point (measured in nautical miles).
Fuel Consumption	The quantity of aircraft fuel needed to travel a certain distance at a certain speed (measured in mpg).
Take-Off Distance	The length of the runway that the airplane must travel before accelerating to a speed where it can produce enough aerodynamic lift to overcome its weight (measured in m).
Landing Distance	The distance needed for an aircraft to touch down, at which point its nose is lowered to the runway and it comes to a stop. (Measured in m).
Price	The amount of money expected to purchase an aircraft (measured in million USD).
Maint. Cost	Costs for maintenance are incurred when performing operations to ensure that the engines and airframe systems are working properly, to replace worn-out or defective parts, and to handle the unplanned failure of systems or components (measured in $/flight hour).
Population	The large number of aircraft operating around the world (measured in unit).
Fleet Commonality	A theory put forth to help an airline to reduce the variety of types in its fleet; it suggests that an airline has a family of engine and/or airframe derivatives.

Questionnaire II is a pairwise comparison between criteria to find out each weight of these criteria, this data will also be used to perform TOPSIS calculations. Calculation of the weight of the criteria is done with the help of online output software and produces the weight of each criterion as shown in Table 4.

Table 4. Weighted of criteria

Criteria	Weight
MTOW	0.137
Payload	0.223
Range	0.207
Fuel Consumption	0.121
Take-Off Distance	0.121
Landing Distance	0.191
Price	0.511
Maint. Cost	0.489
Population	0
Fleet Commonality	1

Questionnaire III is the process of providing an assessment of each alternative aircraft, namely ATR 72-600, ATR 72-500 and Dash 8 Q400. Questionnaire III used a Likert scale, but different from questionnaire I, questionnaire III used a Likert scale of 5 points (1 – 5). The 5-point Likert scale consists of 5 answer choices which will contain two extreme poles and one neutral choice connected to the middle answer choice. This scale is used because it is easily understood by respondents/experts and more importantly, this scale is good for measuring the level of satisfaction or in evaluating the selection of alternatives because there is a neutral assessment. Table 5 shows data from each alternative to the criteria

Table 5. Data from each alternative to the criteria

Criteria	Alternative		
	ATR 72-600	ATR 72-500	Dash 8-Q400
Range (nmi)	900	1000	1120
MTOW (kg)	22800	22000	30500
Fuel Consumption (mpg)	30	42	68
Take-off Distance (m)	1279	1224	1425
Landing Distance (m)	915	1048	1289
Payload (kg)	9200	8165	8400
Aircraft Price (million USD)	24.7	14.4	33.5
Direct Maintenance Cost ($/flight hour)	1200	1200	800
Fleet Commonality	No	Yes	No
Population (unit)	556	339	1249

5. Results and Discussion

The data used in the TOPSIS integration method calculations are the results of the calculation of the weight of the criteria performed with the assistance of online output software and combined with the average of the results of finalizing the questionnaire III by the experts.

5.1 Numerical Results

In Table 6 is the result of compiling a decision matrix with criteria identified as benefits and costs, while in Table 7 is the preparation of a normalized decision matrix.

Table 6. Decision matrix

Alternative	Range	MTOW	Fuel Consumption	Take-Off Distance	Landing Distance	Payload	Price	Maint. Cost	Fleet Commonality	Population
Characteristics	Benefit	Cost	Cost	Benefit	Benefit	Benefit	Cost	Cost	Benefit	Benefit
Weight	0.137	0.223	0.207	0.121	0.121	0.191	0.511	0.489	0	1
ATR 72-600	0	0.321	0.814	0.219	1	1	0	0	0	0
ATR 72-500	0.336	0.354	0.186	0.781	0	0	1	0	1	0
Dash 8 Q400	0.664	0.324	0	0	0	0	0	1	0	1

Table 7. Normalized decision matrix

Alternative	Range	MTOW	Fuel Consumption	Take-Off Distance	Landing Distance	Payload	Price	Maint. Cost	Fleet Commonality	Population
ATR 72-600	0	0.555989	0.97487337	0.2699957	1	1	0	0	0	0
ATR 72-500	0.45150851	0.613146	0.22275976	0.9628615	0	0	1	0	1	0
Dash 8 Q400	0.89226681	0.561185	0	0	0	0	0	1	0	1
Σ Xij2	0.553792	0.333333	0.697192	0.657922	1	1	1	1	1	1
SQRT Σ Xij2	0.74417202	0.57735	0.83498024	0.8111239	1	1	1	1	1	1

In the Table 8 are the normalized matrix weights and the Table 9 shows the negative and positive ideal matrix solutions.

Table 8. Normalized matrix weights

Alternative	Range	MTOW	Fuel Consumption	Take-Off Distance	Landing Distance	Payload	Price	Maint. Cost	Fleet Commonality	Population
ATR 72-600	0	0.123985	0.20179879	0.0326695	0.121	0.191	0	0	0	0
ATR 72-500	0.06185667	0.136732	0.04611127	0.1165062	0	0	0.511	0	0	0
Dash 8 Q400	0.12224055	0.125144	0	0	0	0	0	0.489	0	1

Table 9. Negative and positive ideal matrix solutions

Ideal +/ Ideal -	Range	MTOW	Fuel Consumption	Take-Off Distance	Landing Distance	Payload	Price	Maint. Cost	Fleet Commonality	Population
A+	0.12224055	0.123985	0	0.1165062	0.121	0.191	0	0	0	1
A-	0	0.136732	0.20179879	0	0	0	0.511	0.489	0	0

Table 10 is the distance from the negative and positive ideal solutions, while Table 11 is the result of relative closeness to the positive ideal solution where the first rank is the best alternative.

Table 10. Distance from the negative and positive ideal solutions

Alternative	Si+	Si-
ATR 72-600	1.03087056	0.743367
ATR 72-500	1.1481193	0.529867
Dash 8 Q400	0.55119692	1.147572

Table 11. Relative closeness to the positive ideal solutions

Alternative	Ci+	Rank
ATR 72-600	0.41897812	2
ATR 72-500	0.31577572	3
Dash 8 Q400	0.67553149	1

5.2 Graphical Results

The hierarchy of the main criteria which is a grouping of similar sub-criteria, sub-criteria as well as alternatives for selecting aircraft for cargo purposes can be seen in Figure 1.This hierarchy also provides an overview regarding the relationship between the main criteria and sub-criteria, which in the main criteria for aircraft specifications, there are 6 sub-criteria included in it while the other two main criteria each have 2 sub-criteria.

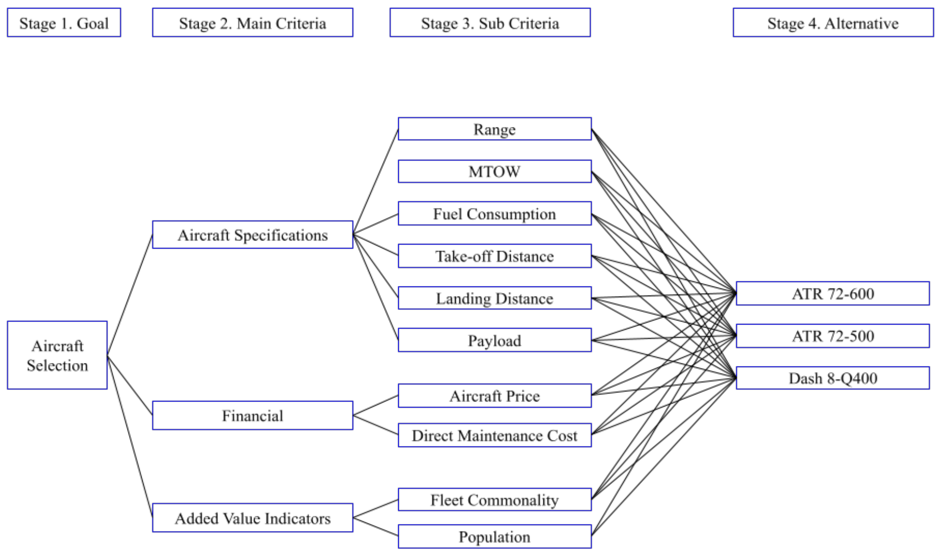

Figure 1. Hierarchy of criteria, sub-criteria and alternatives

5.3 Proposed Improvements

The approach to the aircraft selection model using the integrated fuzzy AHP - TOPSIS method gives better results because it considers the influence of the cost and benefit characteristics as well as positive and negative ideal solutions so that they can distance themselves from negative solutions and get closer to positive results. This gives better selection results. In addition, the selection of criteria that are in accordance with the objectives of selecting aircraft for air cargo charter also gives better results because it eliminates criteria that are not considered.

5.4 Validation

Validation of the criteria and sub-criteria was carried out by testing the reliability of the questionnaire I, the purpose of this test was to find out whether the questionnaire really could be trusted as a data collection tool. In general, reliability testing is a test of the level of trust, in statistical analysis in this study it is necessary to be able to determine the consistency of a questionnaire used. Cronbach's alpha (often denoted by α) is usually used to check internal consistency or reliability of the rating scale which can also be used to check the reliability of questionnaires, values above 0.8 are declared to have high internal reliability and consistency (Vaske, et al, 2016). The results for all questionnaires I showed that Cronbach's Alpha value was 0.96. The tests demonstrated consistency and reliability and satisfactory internal measurements of the questionnaires.

6. Conclusion

From the results of this study, it was found that the best alternative in selecting aircraft in the charter business for cargo purposes is the Dash 8 Q400 type, this type of aircraft has the best cruising range of the three alternatives, the cheapest direct maintenance cost and the largest population. Even though in terms of price it is higher than the three alternatives, fuel consumption is also higher, the take-off and landing distance required is longer and means it requires a longer runway and at the company where the researcher is conducting a case study, this type of aircraft is actually not common and has not been owned, in fact the type of ATR 72-500 which is the most widely owned by this company is 6 units. So, this shows that there are very open opportunities for this company to add types of aircraft in its fleet planning. Future research can consider the MCDM method or other methods and can be compared with this research.

References

Ardil, C., Aircraft Selection Using MultipleCriteriaDecisionMaking Analysis Method with Different DataNormalization Techniques, *International Journal of Industrial and Systems Engineering*, vol. 13, no. 12, 2019.

Ardil, C., Military Fighter Aircraft Selection Using Multiplicative MultipleCriteriaDecision Making Analysis Method, *International Journal of Mathematical and Computational Sciences*, vol. 13, no. 9, 2019.

Ardil, C., Aircraft Selection Process Using Preference Analysis for Reference Ideal Solution (PARIS), *International Journal of Aerospace and Mechanical Engineering*, vol. 14, no. 3, 2020.

Atmosudirdjo, P., *Beberapa Pandangan Umum Tentang Pengambilan Keputusan*, Ghalia Indonesia, Jakarta, 1990.

Chang, D. Y., Applications of the extent analysis method on fuzzy AHP, *European Journal of Operational Research*, vol. 95, pp. 649-655, 1996.

Clark, P., *Buying the Big Jets: Fleet Planning for Airlines*, 2nd Edition, Ashgate Publishing Company, 2007.

Dožić, S. and Kalić, M., An AHP approach to aircraft selection process, *17th meeting of the EURO Working Group on Transportation*, Sevilla, Spain, July 2-4, 2014.

Dožić, S. and Kalić, M., Aircraft Type Selection Problem: Application of Different MCDM Methods, *Advanced Concepts, Methodologies and Technologies for Transportation and Logistics*, 2018.

Dožić, S., Lutovac, T. and Kalić, M., Fuzzy AHP approach to passenger aircraft type selection, *Journal of Air Transport Management*, pp. 1-11, 2017.

Dožić, S. and Kalić, M., Comparison of two MCDM methodologies in aircraft type selection problem, *Transportation Research Procedia*, vol. 10, pp. 910-919, 2015.

Emrouznejad, A. and Ho, W., *Fuzzy Analytic Hierarchy Process*, Taylor & Francis Group, 2017.

Gogus, O. and Boucher, T. O., Strong transitivity, rationality and weak monotonicity in fuzzy pairwise comparisons, *Fuzzy Sets and Systems*, vol. 94, pp. 133-144, 1998.

Hoan, P. V. and Ha, Y., ARAS-FUCOM approach for VPAF fighter aircraft selection, *Decision Science Letters*, vol. 10, pp. 53-62, 2021.

Hwang, C. L. and Yoon, K., Methods for multiple attribute decision making, *Lecture Notes in Economics and Mathematical Systems*, vol. 186, pp. 58-191, 1981.

Kiraci, K. and Akan, E., Aircraft selection by applying AHP and TOPSIS in interval type-2 fuzzy sets, *Journal of Air Transport Management*, vol. 89, 2020.

Kiraci, K. and Bakir, M., Using the Multi Criteria Decision Making Methods in Aircraft Selection Problems and an Application, *Journal of Transportation and Logistics*, vol. 3, no. 1, pp. 13-24, 2018.

Mu, E. and Pereyra-Rojas, M., *Practical Decision Making: An Introduction to the Analytic Hierarchy Process (AHP) Using Super Decisions v2*, Springer International Publishing AG Switzerland, 2017.

Ozdemir, Y., Bsligil, H. and Karaca, M., Aircraft Selection Using Analytic Network Process: A Case for Turkish Airlines, *Proceedings of the World Congress on Engineering 2011*, vol. II, London, U.K., July 6-8, 2011.

Radionovs, A. and Uzgha-Rebrov, O., Comparison of Different Fuzzy AHP Methodologies in Risk Assessment, *Proceedings of the 11th International Scientific and Practical Conference*, pp. 137-142, Rēzekne, Latvia, 2017.

Sales, M., *Aviation Logistics: The dynamic partnership of air freight and supply chain*, Kogan Page, London-Philadelphia, 2016.

Sanchez-Lozano, J. M. and Rodriguez, O. N., Application of Fuzzy Reference Ideal Method (FRIM) to the military advanced training aircraft selection, *Applied Soft Computing Journal*, vol. 88, 2020.

Sun, X., Gollnick, V. and Stumpf, E., Robustness Consideration in Multi-Criteria Decision Making to an Aircraft Selection Problem, *Journal of Multi-Criteria Decision Analysis*, vol. 18, pp. 55-64, 2011.

Torgul, B., Demiralay, E. and Paksoy T., Training Aircraft Selection for Department of Flight Training in Fuzzy Environment, Decision Making,*Applications in Management and Engineering*, vol. 5, no. 1, pp. 264-289, 2022.

Vaske, J. J., Beaman J. and Sponarski, C. C., Rethinking Internal Consistency in Cronbach's Alpha, *Leisure Sciences*, 2016.

Wang, T. C. and Chang, T. H., Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment, *Expert Systems with Applications*, vol. 33, pp. 870-880, 2007.

Wang, J., Fan, K., Su, Y., Liang, S. and Wang, W., Air Combat Effectiveness Assessment of Military Aircraft Using a Fuzzy AHP and TOPSIS Methodology, *Asia Simulation Conference - 7th International Conference on System Simulation and Scientific Computing*, 2008.

Yilmaz, A. K., Malagas, K. N., Jawad, M. and Nikitakos, N., Aircraft selection process with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and AHP Integration, *International Journal of Sustainable Aviation*, vol. 6, no. 3, 2020.

Biographies

Luhur Prakoso Prabowo, S.T. is a postgraduate student of Industrial Engineering, Faculty of Engineering at the University of Indonesia (UI). Taking a study expertise group on Production Systems and Logistics, also interested in Aviation Supply Chain.In addition to having an undergraduate engineering education background, he also has a Commercial Pilot License (CPL),Certified Supply Chain Analyst (CSCA) and Certified Data Analyst (CDA).

Dr. Ir. T. Yuri M. Zagloel, M.Eng.Sc. is an active professor in the Department of Industrial Engineering, Faculty of Engineering at the University of Indonesia (UI). He began his university education in Mechanical Engineering at the University of Indonesia, where he graduated in 1987, and then continued his studies at the University of New South Wales (UNSW) in Sydney, Australia, where he received his master's degree (M.Eng.Sc.) in 1991. In 2000, he completed his educational paths by completing his doctoral degree at the University of Indonesia.His research interests are in Quality Management, Production System and Supply Chain Management (SCM). He has taught several courses in Industrial Engineering including Introduction to Industrial Engineering, Engineering Ethics, Logistics and Inventory Management, also Total Quality Management (TQM). He has supervised many under-graduate and post-graduate students to do research in these areas. Moreover, he has published numerous journal papersand conference articles.