CHOOSING THE BEST TRAINING AIRCRAFT FOR A FLIGHT TRAINING ORGANIZATION BY MULTI CRITERIA DECISION MAKING METHODS

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Abstract: In today's world, now it is more important to make fair judgements and give right decisions for companies and organizations. The aim of this paper is to choose the best training aircraft for a flight training organization by using Analytic Hierarchy Process (AHP) and Technique Order Preference by Similarity to the Ideal Solution (TOPSIS). Sensitivity analysis is carried out to see possible consequences. Results show that the best aircraft among alternatives is the Daimond DA 42 VI for the flight training organization.

Keywords: Decision making, MCDM, aircraft

Introduction

Airline companies and educational institutes are both organizations that should consider undergoing economic status, climate, potential benefits etc. when it comes to purchasing for the company, especially for purchasing on aircrafts. When purchasing for aircrafts, a flight training organization must consider its limited budget, safety of employee and students, technical parameters and specifications that they need and efficiency of the aircraft in general. For significant and reasonable decisions, flight training organizations should analyze these conflicting criteria such as budget and technological features carefully.

In literature search, Esposito et al. (2013), proposed a hybrid model for regional aircraft evaluation, based on the two main approaches, the Analytic Hierarchy Process (AHP) and the Fuzzy Set Theory (FST). They proposed a model that considers not only traditional characteristics (direct and indirect operative costs and technical performance such as the cruise speed) but also includes a variety of aspects whose importance is increasing, such as comfort. Dožić and Kalić (2014), proposed a solution for aircraft type(s) selection problem for known route network and forecasted air travel demand by using the Analytic Hierarchy Process (AHP). They have seen that sensitivity of *CI* and *CR* is significant to the changes of different judgements in the comparison matrix for the first level, while solution (rank of alternatives) sensitivity is almost insignificant to these changes.

Materials and Methods

In this study the best aircraft among alternatives is chosen based on flight training and organizational needs. In order to include basic and needed criteria, both qualitative and quantitative parameters are used. In this context evaluation of two methods proposed in literature the Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are applied by using Expert Choice, Super Decisions and Microsoft Excel programs.

In AHP method, first, problem should be defined and hierarchical representation of decision system should be formed. This hierarchical form should include overall objective, criterias that will affect the decision and some predetermined alternatives. Second, alternatives and criteria should be pairwise compared. In this step, there are two kinds of pairwise comparisons. One is the pairwise comparison that one should compare the alternatives with respect to the criterias and the other kind of pairwise comparison is the one that one should compare the criterias with respect to the decision objective. After obtaining matrix A from pairwise comparisons between alternatives with respect to the criterias, normalized A matrix is computed. Next, the weight matrix W is computed. This procedure is repeated for criterias too. And than Consistency Ratio (CR) is computed to see if there is any inconsistency. CR≤0,1 is allowed. For further information one can study the papers performed by Thomas L Saaty titled "How to make a decision: The Analytic Hierarchy Process" (Saaty, 1990) and "Decision making with the analytic hierarchy process" (Saaty, 2008).

Saaty and Ozdemir (2003) stated that, when the number of the elements are more than seven, the resulting

incostistency is too small for humans to obtain the element which causes the biggest inconsistency to fix it. So, for AHP method, elements no more than seven are used in this study. Saaty and Sağır Özdemir (2015) also stated that there can be even one judge to evaluate the criteria weights if he/she is experienced and efficient enough for the subject.

TOPSIS method is applied in six steps as follows:
Step 1: Calculate the normalized values r_{ij} and matrix N.

$$r_{ij=x_{ij}}\sqrt{\sum_{i-1}^{m} x_{ij}^2} \quad \text{i=1,…,m} \qquad \text{j=1,…,n}$$

Step 2: Calculate the weighted normalized decision matrix V. Here, w_j is the weight of the j^{th} criteria.

$$V_{ij} = r_{ij} \times w_j \qquad \text{i=1,…,m} \qquad \text{j=1,…,n}$$

Step 3: Determine the ideal and negative ideal solutions, A^* and A^- respectively.

$$A^* = \left\{\left(max_{i\ V_{ij}} \middle| j \in C_b\right), min_{i\ V_{ij}} \middle| j \in C_c\right\} = \{V_j^* | j = 1,2,\dots,m\}$$

$$A^- = \left\{\left(min_{i\ V_{ij}} \middle| j \in C_b\right), max_{i\ V_{ij}} \middle| j \in C_c\right\} = \{V_j^- | j = 1,2,\dots,m\}$$

Step 4: Calculate the separation measures of each alternative from the positive ideal solution and the negative ideal solution.

$$S_i^* = \sqrt{\sum_{j=1}^{m} \left(V_{ij} - V_j^*\right)^2} \ , j = 1,\dots,m$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} \left(V_{ij} - V_j^-\right)^2} \ , j = 1,\dots,m$$

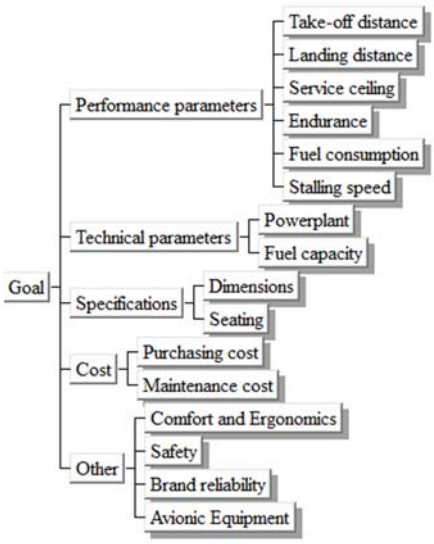
Step 5: Calculate the relative closeness to the ideal solution.

$$C_i^* = \frac{S_i^- + S_i^*}{S_i^-}$$

Implementation

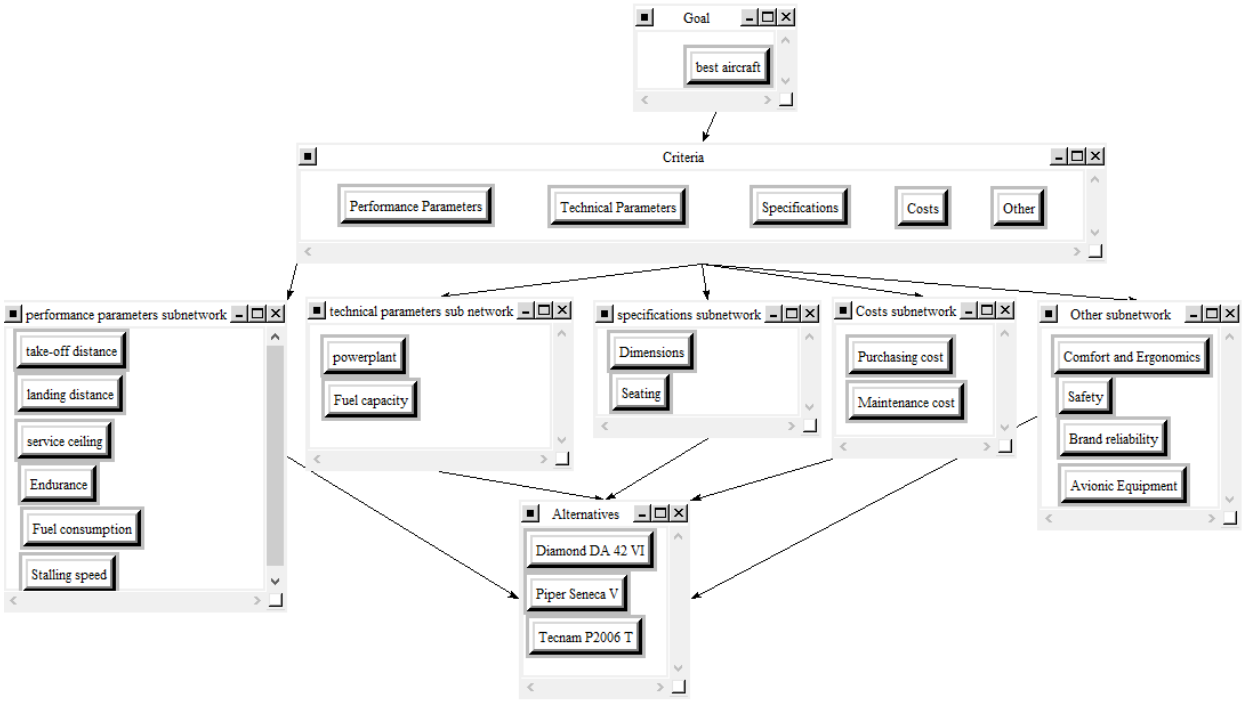
This study deals with giving the right decision to purchase an aircraft for a flight training organization. Within this context, 3 different types of aircraft, 5 main criteria and 16 sub-criteria are defined both by literature search and an expert's knowledge. In this study the expert is a well experienced aviation theoretical lesson teacher who is also the head of the ground education department in a private flight school.
After determining the goal, criteria and alternatives, the analytic hierarchy structure of the proposed system is set up as shown in Figure 1.

Figure 1. The analytic hierarchy structure of the system



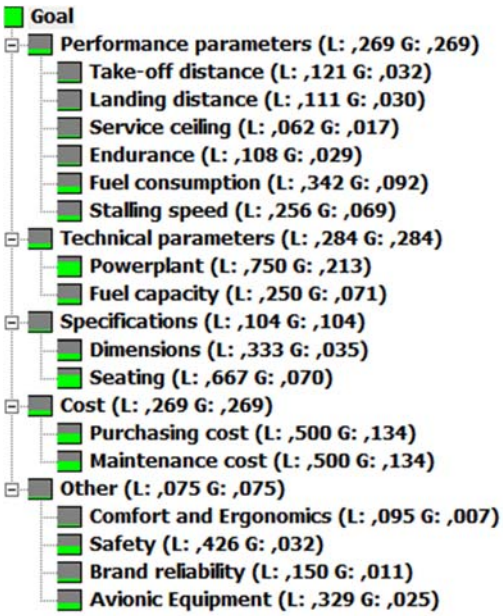
One can also rebuild this hierarchy structure using Super Decisions program for a more relevant image as shown in Figure 2. Here one can see that 3 alternatives are Diamond DA 42 VI, Piper Seneca V and Tecnam P2006T.

Figure 2. Hierarchy structure of the system by Super Decisions program



After setting up the hierarchy structure, pairwise comparisons are made and final weights of the criteria are obtained as seen in Figure 3.

Figure 3. Final local and global weights of the crtieria



After determining the weights of the criteria by AHP, TOPSIS method is applied. For this purpose, the decision maker rated all alternatives with respect to all criteria using Saaty's fundamental scale. Standard decision matrix is formed and normalized as seen in Table 1.

Table 1: Normalized decision matrix (N)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
A1	0,625	0,514	0,647	0,873	0,436	0,226	0,780	0,408	0,577	0,485	0,588	0,588	0,376	0,577	0,436	0,588
A2	0,625	0,514	0,740	0,436	0,218	0,566	0,390	0,816	0,577	0,728	0,784	0,784	0,847	0,577	0,873	0,784
A3	0,468	0,686	0,185	0,218	0,873	0,793	0,488	0,408	0,577	0,485	0,196	0,196	0,376	0,577	0,218	0,196

Normalized decision matrix is multiplied by the weights of the criteria and positive, negative ideal solutions, separation measures are calculated.

Results and Discussion

At the final step, relative closeness to the ideal solution are calculated and alternatives are lined up with respect to their closeness to the ideal solution as seen in Table 2.

Table 2: Relative closeness of alternatives to the ideal solution.

A1	0,576514
A2	0,475493
A3	0,404159

Here, A1 refers to Diamond DA 42 VI, A2 refers to Piper Seneca V and A3 refers to Tecnam P2006 T. As one can see, the best aircraft is Diamond DA 42 VI among others.

Conclusion

In this paper 2 multi-criteria decision making methods – AHP and MCDM – are applied to the problem titled "choosing the best training aircraft for a flight training organization." As a conclusion, both methods helped the decision maker to make a fair judgement and give the best decision. Here, the best alternative among others is the Diamond DA 42 VI aircraft.

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