An Analysis of Decision Criteria for the Selection of Military Training Aircrafts

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Abstract The Spanish Minister of Defense needs to replace the current military training aircrafts by other models to meet current training needs in the Spanish Air Force Academy. In order to know the main features that the candidate aircrafts should have, there is a need to take into account the knowledge and experience of experts in this specific field, such as trained test pilots and flight instructors. In this way, it will be possible to recognize the main technical criteria to consider. This study shows a case study that allowed obtaining not only the preferences of an expert's group, but also the importance of the considered criteria. Given that the criteria information provided by the experts has different nature, with qualitative criteria (human factors, flying and handling qualities, etc.) coexisting with quantitative criteria (service ceiling, stalling speed, endurance, etc.), the joint use of linguistic labels and numerical values is needed. Therefore, a survey focused on the fuzzy AHP (Analytic Hierarchy Process) methodology is proposed to extract the knowledge from the experts group and finally obtain a unique set of weights for the criteria.

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1 Introduction

Nowadays, the Air Force Academy uses two training aircrafts: the model ENAER T.35C Tamiz for elementary basic education and the model CASA C-101 Aviojet for advanced basic education. These aircraft have been operating from the 1980s so that, as a result of the continuous advancement of aviation technology and the high number of flight hours that they have seen, in the near future it will be necessary to replace them by other models to meet current training needs.

From the point of view of training aircrafts and, as occurs in the subsequent stages of design [1, 2], decision-making is an intellectual activity which is necessary and essential to face. Before taking any decisions, facts, knowledge and experience should be gathered to assess the context of the problem. In this type of decision-making process, a large number of essential criteria is involved. To resolve them, it is therefore advisable to employ tools such as Multi-Criteria Decision Making (MCDM), a process whose use is widespread today, not only in the military field [3–5], but also in many research fields [6–8].

In addition, when selecting the best training aircraft a number of criteria of different nature should be taken into account, such as quantitative criteria (service ceiling, stall speed, fuel range, etc.), and qualitative criteria (cockpit ergonomics, feelings of instructor, etc.). In order to model and evaluate the latter type of criteria, fuzzy logic techniques [9–13] are a good alternative, not only to operate in an isolated way but also combined with pseudo-Delphi techniques and MCDM methods (AHP [14]; TOPSIS [15]; ELECTRE [16], etc.). Although some of the aforementioned multi-criteria methods are able to apply fuzzy logic and evaluate the potential alternatives, the AHP methodology also allows obtaining the weight of the criteria. That is the main reason why in this study case a pseudo-Delphi technique has been combined with fuzzy AHP methodology.

From the point of view of the Spanish Air Force, the Air Staff and the Logistics Support Command of this force are the main decision-makers. Nevertheless, it is advisable to make a preliminary assessment taking into account the most significant technical criteria which also reflect the experience of important expert groups such as trained test pilots and flight instructors of the Spanish Air Force.

Therefore, our aim here is to determine the relative importance of the main technical criteria and then, to transform such importance into weights that should be later used in a MCDM scheme. The problem will be solved using the AHP methodology to obtain the weights of the criteria that influence the decision. Furthermore, given that the criteria are both qualitative and quantitative, both methods will be combined with fuzzy logic through the design and development of a survey to experts in the field of military training aircraft.

This chapter is divided into four sections: Sect. 2 will define the criteria that influence the decision-making, in Sect. 3 the fundamentals of fuzzy sets and the AHP methodology will be described. Section 4 will explain the way in which the weights of the considered criteria are obtained and the results. The final section will detail the conclusions of this study.

2 Decision Criteria for Evaluating Military Training Aircraft

The mission of the Spanish Air Force Academy is to train future officers of the Spanish Air Force by providing them with academic, military and aeronautical teaching. Although today there are many aircraft, they are usually classified according to their use [17]. In the case of the Spanish Air Force Academy, these aircrafts should have specific features that allow the future officers to carry out their basic and advanced education [18]. Due to that, it is highly advisable to identify the main technical criteria that influence the decision; these data have been obtained from [17, 19–22] and an advisory group composed by instructors and flight personnel of the Air Force Academy. The chosen criteria are the following:

- C_1: Service ceiling (ft), the highest operating altitude at which the maximum achievable rate of climb is 100 ft/min and the aircraft can bear the atmosphere and operate efficiently.
- C_2: Cruising speed (kt), the constant and uniform speed in which an aircraft is able to fly with normal conditions of pressure and temperature.
- C_3: Stalling speed (kt), the minimum speed in which the wings maintain lift at flameout.
- C_4: Endurance (minutes), the maximum time in which an aircraft can remain in the air until all fuel has expired.
- C_5: Positive Limit Load Factor (+ G), the maximum value of positive acceleration forces which can withstand the airframe.
- C_6: Negative Limit Load Factor (− G), the minimum value of positive acceleration forces which it can withstand the airframe.
- C_7: Take-off distance (ft), the minimum distance required by the aircraft to accelerate along the runway until it reaches a speed at which it can generate sufficient aerodynamic lift to overcome its weight (in standard sea level conditions).
- C_8: Landing distance (ft), the minimum distance required by the airplane to land (in standard sea level conditions).
- C_9: Human factors: the comfort conditions inside the cockpit (beginner pilot and instructor positions)
- C_{10}: Flying and handling qualities, confidence that the instructor or beginner pilot on the plane to perform complex training exercises.
- C_{11}: Security systems, devices of the aircraft for responding face with setbacks or unexpected situations (ejection systems, sensors, etc.)
- C_{12}: Maneuvering Capability, software tools capable of being configured and adapted to several models of education (elementary and advanced stage)

In order to determine the relative importance of these technical criteria, we have access to a group of experts (trained test pilots and flight instructors of the Spanish Air Force) who will answer a survey based on the application of the methodology described.

3 Methodology

Fuzzy Sets

The fuzzy set theory, introduced by Zadeh [9] to deal with vague, imprecise and uncertain problems has been used as a modelling tool for complex systems that can be controlled by humans but are hard to define precisely. Examples of fuzzy sets are classes of objects (entities) characterized by such adjectives as large, small, serious, simple, approximate, etc. The main reason for this is that in a real world, there are not crisp or real boundaries which separate those objects which belong to the classes in question from those which do not [23]. A collection of objects (universe of discourse) X has a fuzzy set A described by a membership function f_A with values in the interval [0,1] [24].

In this chapter, we only make reference to the operations on a triangular membership function through the fuzzy number sets that will be used in the study case. The basic theory regarding Triangular Fuzzy Numbers (TFN) is described in detail in [9]. Herein, we only make reference to the operations on fuzzy sets that we will use in the application.

Definition 1.- A_1 and A_2 are two TFN defined by the triplets (a_1, b_1, c_1) and (a_2, b_2, c_2), respectively. For this case, the necessary arithmetic operations with positive fuzzy numbers are:

(a) Addition:

$$A_1 \oplus A_2 = [a_1 + a_2, b_1 + b_2, c_1 + c_2] \tag{1}$$

(b) Subtraction:

$$A_1 \Theta A_2 = A_1 + (-A_2) = [a_1 - c_2, b_1 - b_2, c_1 - a_2] \tag{2}$$

(c) Multiplication:

$$A_1 \otimes A_2 = [a_1 \times a_2, b_1 \times b_2, c_1 \times c_2] \tag{3}$$

(d) Division:

$$A_1 \phi A_2 = [(a_1, b_1, c_1) \cdot (1/c_2, 1/b_2, 1/a_2)] \tag{4}$$

When $0 \neq [a_2, b_2, c_2]$

(e) Scalar Multiplication:

$$k \circ T_1 = (k \circ a_1, k \circ b_1, k \circ c_1) \tag{5}$$

(f) Root:

$$T_1^{1/2} = \left[a_1^{1/2},\ b_1^{1/2},\ b_1^{1/2}\right] \tag{6}$$

Analytic Hierarchy Process (AHP)

The AHP methodology, proposed by Saaty [14], has been accepted by the international scientific community as a robust and flexible MCDM tool to deal with complex decision problems. Basically, AHP has three underlying concepts:

- Structuring the complex decision as a hierarchy of goal, criteria and alternatives.
- Pair-wise comparison of elements at each level of the hierarchy with respect to each criterion on the preceding level, and finally
- Vertically synthesizing the judgements over the different levels of the hierarchy.

AHP attempts to estimate the impact of each one of the alternatives on the overall objective of the hierarchy. In this case, we shall only apply the method to obtain the criteria weights.

We assume that the quantified judgements provided by the decision-maker on pairs of criteria (C_i, C_j) are contained in an n x n matrix as follows:

$$C = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_m \end{matrix} \begin{pmatrix} & C_1 & C_2 & \cdots & C_n \\ & c_{11} & c_{12} & \cdots & c_{1n} \\ & c_{21} & c_{22} & \cdots & c_{2n} \\ & \vdots & \vdots & \ddots & \vdots \\ & c_{m1} & c_{m2} & \cdots & c_{mn} \end{pmatrix}$$

For instance, the c_{12} value represents an approximation of the relative importance of C_1 to C_2, i.e., $c_{12} \approx (w_1/w_2)$. This can be generalized and the statements below can be concluded:

- $c_{ij} \approx (w_i/w_j),\ i, j = 1, 2, \ldots, n$

- $c_{ii} \approx (w_i/w_i) = 1,\ i = 1, 2, \ldots, n$

- If $c_{ij} = \alpha,\ \alpha \neq 0$, then $c_{ji} = 1/\alpha,\ i = 1, 2, \ldots, n$
- If C_i is more important than C_j, then $c_{ij} \cong (w_i/w_j) > 1$

Table 1 Fuzzy Scale of valuation in the pair-wise comparison process [25]

Labels	Verbal judgments of preferences between criterion i and criterion j	Triangular fuzzy scale and reciprocals
(II)	Ci and Cj are equally important	(1, 1, 1)/(1,1,1)
(M + I)	Ci is slightly more important than Cj	(2, 3, 4)/(1/4,1/3,1/2)
(+I)	Ci is strongly more important than Cj	(4, 5, 6)/(1/6,1/5,1/4)
(Mu + I)	Ci is very strongly more important than Cj	(6, 7, 8)/(1/8,1/7,1/6)
(Ex + I)	Ci is extremely more important than Cj	(8, 9, 9)/(1/9,1/9,1/8)

This implies that the matrix C should be a positive and reciprocal matrix with 1's on the main diagonal. Hence, the decision maker only needs to provide value judgments in the upper triangle of the matrix. The values assigned to c_{ij} according to the Saaty scale usually lie in the interval of 1-9 or their reciprocals.

It can be shown that the number of judgments (L) needed in the upper triangle of the matrix is:

$$L = n(n-1)/2 \tag{7}$$

where n is the size of the matrix C.

As the reader can observe, there are both qualitative and quantitative criteria, so it is necessary to transform the Saaty's scale to fuzzy numbers. Therefore, Table 1 presents the decision-maker's linguistic preferences in the fuzzy pairwise comparison process.

The vector of weights is the eigenvector corresponding to the maximum eigenvalue "λ_{max}" of the matrix C. The traditional eigenvector method of estimating weights in AHP yields a way of measuring the consistency of the referee's preferences arranged in the comparison matrix.

In AHP problems, where the values are fuzzy not crisp, instead of λ using the eigenvector as an estimator of the weight, we will use the geometric normalized average, expressed by the following expression:

$$w_i = \frac{\left(\prod_{j=1}^{n}\left(a_{ij}, b_{ij}, c_{ij}\right)\right)^{1/n}}{\sum_{i=1}^{m}\left(\prod_{j=1}^{n}\left(a_{ij}, b_{ij}, c_{ij}\right)\right)^{1/n}} \tag{8}$$

where, (a_{ij}, b_{ij}, c_{ij}) is a fuzzy number.

Additionally, to obtain the weight vector, the normalizing operation must be used; this will be achieved through expression (9).

$$\left(w_{c_{ia}}, w_{c_{ib}}, w_{c_{ic}}\right) = \left[\frac{c_{ia}}{\sum_{i=1}^{n} c_{ic}}, \frac{c_{ib}}{\sum_{i=1}^{n} c_{ib}}, \frac{c_{ic}}{\sum_{i=1}^{n} c_{ia}}\right] \tag{9}$$

4 Determining the Criteria Importance

Not all the criteria which have influence in this kind of decision problems have the same importance. Besides, although there are decision problems that could be similar, the selection of the criteria depend of the specific necessities of each country. Therefore, not only it is important to carry out an appropriate selection of criteria, but also to choose the way of obtaining their weights. For instance, previous studies [22, 26] have determined the weights of criteria via direct assignment. However, in this study, the way of obtaining these weights has been through preferences of an experts group.

The group of experts involved in the decision process consisted of six experts specialized in this specific field (three trained test pilots and three flight instructors of the Spanish Air Force).

According to expression (7), 66 questions should be answered by each one of the experts. Despite the huge amount of work needed, it is possible that some inconsistent matrices can be generated. In order to decrease the inconsistency in this specific case study and to reduce the amount of work required for each expert, we reduced the number of questions in such a way that no loss of relevant information is produced [27, 28]. Therefore, we propose an alternative method, which only requires making $(n - 1)$ comparisons. For that purpose, a questionnaire similar to [29] was carried out. This questionnaire also allow us to reduce the uncertainty and imprecision in the proposed problem.

4.1 Fuzzy-Delphi-AHP Survey

The methodology used for the extraction of the experts' knowledge is a pseudo-Delphi technique, since the members who are part of the decision-making do not interact at any time. In order to do this, a series of questionnaires were distributed among the six participants in this process so that they could choose the answers they considered most appropriate, in order to reduce the uncertainty and vagueness involved with the problem presented.

The questionnaire designed has two clearly different parts. The first one consists of the presentation of the decision problem where the variables employed and the work methods to carry out are detailed. The experts were asked if the approach made to solve the problem was suitable and if they agreed with it. The six experts gave an affirmative answer and therefore it was possible to carry on with the survey (second part of the questionnaire).

It is known that if one criterion is more important than another, it should be considered that said criterion has a greater weight than the other. Therefore, the rest of the survey was focused on the following group of questions:

Table 2 Order of importance of criteria for each of the experts

E_1	$C_{11} = C_{10} > C_9 > C_{12} = C_1 > C_2 = C_3 = C_7 = C_8 > C_4 = C_5 = C_6$
E_2	$C_9 = C_{10} = C_{11} > C_3 = C_7 = C_8 > C_4 = C_1 = C_2 = C_5 = C_6 > C_{12}$
E_3	$C_{11} > C_{10} = C_9 = C_{12} > C_4 > C_3 = C_5 = C_2 = C_7 > C_6 = C_1 = C_8$
E_4	$C_{11} > C_{12} = C_7 = C_9 > C_{10} = C_8 = C_2 > C_1 = C_3 = C_4 > C_5 = C_6$
E_5	$C_{11} > C_9 = C_{10} > C_1 = C_2 = C_3 = C_4 = C_5 = C_6 = C_7 = C_8 = C_{12}$
E_6	$C_{11} > C_9 = C_{10} = C_{12} = C_2 = C_3 > C_7 = C_8 = C_5 > C_6 = C_4 = C_1$

a. ***Do you think that the twelve criteria considered have the same importance?***

If the answer is affirmative, the weight associated with criterion C_j is $w_j = 1/m$, $j = 1,2,\ldots,m$. If on the contrary, experts consider that not all the criteria have the same importance, then it is appropriate to proceed to the next question of the survey.

The next step will be to find the extent to which one criterion is more important than another, this degree of importance will be analyzed to be able to assign a weight to each criterion. For example, when indicating that a particular criterion has a higher weight than the rest of the criteria, it is declared that this is the most important criterion. Forthwith, the weights of the criteria will be used to quantify their importance.

The six experts have considered that certain criteria should have a greater weight than others. Therefore, those weights need to be determined.

b. ***Write the order of importance among the twelve criteria*** (Table 2).

As can be seen in Table 2, the six experts believe the importance of the criteria to be different, although they differ in the order of importance of the criteria. Analyzing the above table, experts indicate that criteria C_9, C_{10} and C_{11} are the most important criteria. Due to that, these criteria will have larger weights.

Once the expert has indicated the order of importance, the next question would be considered:

c. ***Compare the criterion chosen in first place with respect to that considered secondly and successively, using the following labels, {(II), (M +), (+I), (Mu + I), (Ex + I)} according to the meanings in*** Table 1.

To determine the weights of the criteria, as has been discussed, a pair-wise comparison has been made. Using Expert 1 as an example, in Fig. 1 his appreciation by pair-wise comparison is shown.

The meaning is as follows: criterion C_{11} is extremely more important than C_4, C_5 and C_6, with respect to C_2, C_3, C_7 and C_8 it is very strongly more important,

$$\begin{array}{c} \\ C_{11} \end{array}\begin{array}{cccccccccccc} C_{11} & C_{10} & C_9 & C_{12} & C_1 & C_2 & C_3 & C_7 & C_8 & C_4 & C_5 & C_6 \\ \left[II\right. & II & M+I & +I & +I & Mu+I & Mu+I & Mu+I & Mu+I & Ex+I & Ex+I & \left.Ex+I\right] \end{array}$$

Fig. 1 Valuations given by E_1

$$\begin{array}{ccccccccccccc} & C_{11} & C_{10} & C_{9} & C_{12} & C_{1} & C_{2} & C_{3} & C_{7} & C_{8} & C_{4} & C_{5} & C_{6} \\ C_{11} & [(1,1,1) & (1,1,1) & (2,3,4) & (4,5,6) & (4,5,6) & (6,7,8) & (6,7,8) & (6,7,8) & (6,7,8) & (8,9,9) & (8,9,9) & (8,9,9)] \end{array}$$

Fig. 2 Matrix of decision making for E_1

$$\begin{matrix} C_{11} \\ C_{10} \\ C_{9} \\ C_{12} \\ C_{1} \\ C_{2} \\ C_{3} \\ C_{7} \\ C_{8} \\ C_{4} \\ C_{5} \\ C_{6} \end{matrix} = \begin{bmatrix} C_{11} \\ (1,1,1) \\ (1,1,1) \\ (1/4,1/3,1/2) \\ (1/6,1/5,1/4) \\ (1/6,1/5,1/4) \\ (1/8,1/7,1/6) \\ (1/8,1/7,1/6) \\ (1/8,1/7,1/6) \\ (1/8,1/7,1/6) \\ (1/9,1/9,1/8) \\ (1/9,1/9,1/8) \\ (1/9,1/9,1/8) \end{bmatrix} = \begin{bmatrix} (0.247, 0.275, 0.293) \\ (0.247, 0.275, 0.293) \\ (0.062, 0.092, 0.146) \\ (0.041, 0.055, 0.073) \\ (0.041, 0.055, 0.073) \\ (0.031, 0.039, 0.049) \\ (0.031, 0.039, 0.049) \\ (0.031, 0.039, 0.049) \\ (0.031, 0.039, 0.049) \\ (0.027, 0.031, 0.037) \\ (0.027, 0.031, 0.037) \\ (0.027, 0.031, 0.037) \end{bmatrix}$$

Fig. 3 Criteria weight for E_1

with respect to C_{12} and C_1 it is strongly more important, with respect to C_9 it is slightly more important and with respect to C_{10} is equally important.

This, translated to the fuzzy numbers according to Table 1, gives the results shown in Fig. 2.

Taking into account [30] and operation (9), the weights of the considered criteria are obtained (Fig. 3).

The information detailed above for E_1 would also be carried out for the other experts. The normalized weights associated with the corresponding criterion C_j, $j = 1,2,\ldots,12$ given by each of the experts can be seen in Table 3.

Analyzing the above table, criterion C_{11} (security systems) has the maximum score for each of the experts; this criterion is equally important to criterion C_{10} (flying and handling qualities) for expert 1, and equally important to criteria C_{10} and C_9 (human factors) for expert 2. This expert also considers as the second most important criteria C_3 (stalling speed), C_7 (take-off distance) and C_8 (landing distance). Conversely, the least important criterion for this expert is C_{12} (tactical capability).

The weights of the criteria for expert 3 are similar. According to this expert, criterion C_{11} is also the highest rated, with the second most important criteria being C_9, C_{10} and C_{12}. The least important criteria are C_1 (service ceiling), C_6 (negative limit load factor) and C_8.

Table 3 Weights of criteria for the six experts (heterogeneous aggregations)

	Normalized (Expert 1)			Normalized (Expert 2)			Normalized (Expert 3)		
C1	[0.041	0.055	0.073]	[0.023	0.030	0.037]	[0.029	0.036	0.045]
C2	[0.031	0.039	0.049]	[0.023	0.030	0.037]	[0.033	0.046	0.061]
C3	[0.031	0.039	0.049]	[0.046	0.069	0.111]	[0.033	0.046	0.061]
C4	[0.027	0.031	0.037]	[0.023	0.030	0.037]	[0.044	0.064	0.091]
C5	[0.027	0.031	0.037]	[0.023	0.030	0.037]	[0.033	0.046	0.061]
C6	[0.027	0.031	0.037]	[0.023	0.030	0.037]	[0.029	0.036	0.045]
C7	[0.031	0.039	0.049]	[0.046	0.069	0.111]	[0.033	0.046	0.061]
C8	[0.031	0.039	0.049]	[0.046	0.069	0.111]	[0.029	0.036	0.045]
C9	[0.062	0.092	0.146]	[0.183	0.207	0.223]	[0.066	0.107	0.182]
C10	[0.247	0.275	0.293]	[0.183	0.207	0.223]	[0.066	0.107	0.182]
C11	[0.247	0.275	0.293]	[0.183	0.207	0.223]	[0.264	0.322	0.364]
C12	[0.041	0.055	0.073]	[0.020	0.023	0.028]	[0.066	0.107	0.182]
	Normalized (Expert 4)			Normalized (Expert 5)			Normalized (Expert 6)		
C1	[0.031	0.044	0.059]	[0.039	0.058	0.083]	[0.036	0.040	0.049]
C2	[0.042	0.062	0.088]	[0.039	0.058	0.083]	[0.053	0.072	0.098]
C3	[0.031	0.044	0.059]	[0.039	0.058	0.083]	[0.053	0.072	0.098]
C4	[0.031	0.044	0.059]	[0.039	0.058	0.083]	[0.036	0.040	0.049]
C5	[0.028	0.034	0.044]	[0.039	0.058	0.083]	[0.040	0.052	0.066]
C6	[0.028	0.034	0.044]	[0.039	0.058	0.083]	[0.036	0.040	0.049]
C7	[0.063	0.103	0.176]	[0.039	0.058	0.083]	[0.040	0.052	0.066]
C8	[0.042	0.062	0.088]	[0.039	0.058	0.083]	[0.040	0.052	0.066]
C9	[0.063	0.103	0.176]	[0.059	0.096	0.167]	[0.053	0.072	0.098]
C10	[0.042	0.062	0.088]	[0.059	0.096	0.167]	[0.053	0.072	0.098]
C11	[0.250	0.308	0.351]	[0.235	0.288	0.333]	[0.320	0.362	0.393]
C12	[0.063	0.103	0.176]	[0.039	0.058	0.083]	[0.053	0.072	0.098]

Apart from criteria C_9 and C_{12}, expert 4 also considers C_7 as the second most important criterion. The least important criteria for this expert are C_5 and C_6 (positive and negative limit load factors).

According to expert 5, criteria C_9 and C_{10} are the second most important criteria, while for that expert the remaining criteria have the same importance.

Expert 6 estimates that there is a criteria group consisting of C_2 (cruising speed), C_3, C_9, C_{10} and C_{12} which have the following score after that of the highest criterion (C_{11}). The least important criteria are C_1, C_4 (endurance) and C_6.

In order to unify the weights of the obtained criteria and to stablish a specific weight for each one of the criteria, a homogeneous aggregation will be carried out. i.e., all experts are equally important in the decision, as a measure of aggregation the arithmetic average will be used (expression 10).

Table 4 Weights of criteria through experts' homogeneous aggregation

Experts' homogeneous aggregation			
C_1	[0.0332	0.0437	0.0578]
C_2	[0.0368	0.0511	0.0693]
C_3	[0.0389	0.0547	0.0768]
C_4	[0.0334	0.0444	0.0593]
C_5	[0.0317	0.0416	0.0545]
C_6	[0.0304	0.0380	0.0493]
C_7	[0.0419	0.0611	0.0909]
C_8	[0.0378	0.0525	0.0737]
C_9	[0.0809	0.1129	0.1653]
C_{10}	[0.1084	0.1366	0.1750]
C_{11}	[0.2499	0.2937	0.3262]
C_{12}	[0.0471	0.0697	0.1067]

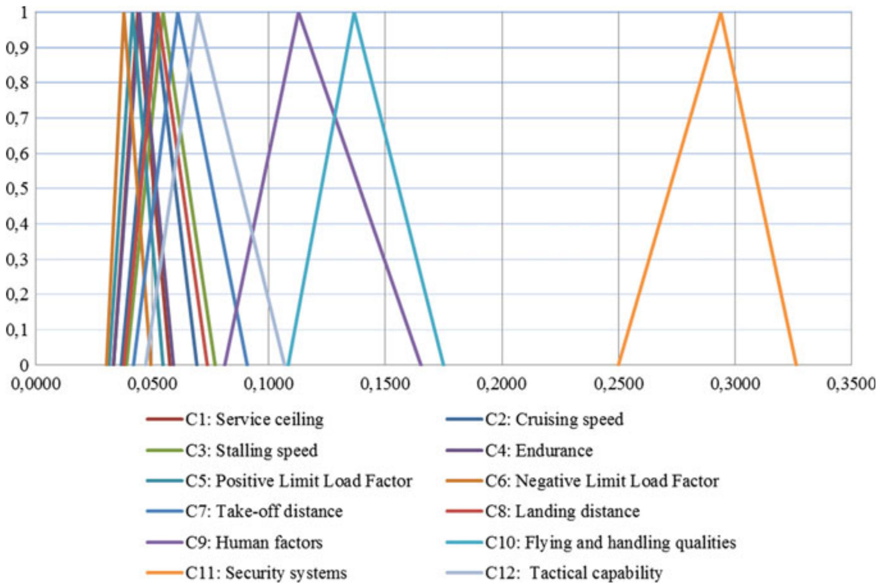

Fig. 4 Graphic representation (experts' homogeneous aggregation)

$$(\bar{X}_{ia}, \bar{X}_{ib}, \bar{X}_{ic}) = \left[\frac{\sum_{i=1}^{n} X_{ia}}{n}, \frac{\sum_{i=1}^{n} X_{ib}}{n}, \frac{\sum_{i=1}^{n} X_{ic}}{n}\right] \quad (10)$$

By the homogeneous aggregations indicated, the weights of the criteria will be obtained, taking into account the entire decision-making group. Therefore, the values obtained for the selection problem of the best military training aircraft are those indicated in Table 4 and Fig. 4.

Through homogeneous aggregation it is observed that the most important criteria are C_{11} (security systems), C_{10} (flying and handling qualities) and C_9 (human factors). According to experts 1, 2, 3, 5 and 6 these criteria are also the most important criteria. The only expert who lightly differs of the rest of experts is expert 4. This expert indicates as the second criteria in importance order the criteria C_7 (take-off distance), C_9 and C_{12} (tactical capability) while criterion C_{10} is moved to the third position.

The following criteria group in importance is comprised of two criteria; C_7 (take-off distance), and C_{12} (tactical capability) which are the criteria that expert 4 located in the second position. Whereas the least important criteria are C_5 and C_6 (positive and negative limit load factors).

5 Conclusions

With respect to the applied methodology, it is worth highlighting that, carrying out the extraction of knowledge from an experts group in this specific field (trained test pilots and flight instructors of the Spanish Air Force) has allowed to combine the Delphi method and the fuzzy logic techniques with a well-known decision making tool like AHP methodology.

Furthermore, it has not only been possible to select and define a list of criteria which influence the selection problem, but also to obtain their coefficients of importance through the AHP methodology.

Through the homogeneous aggregation, it is observed that the most important criteria when selecting the best military training aircraft are C_{11} (security systems), C_{10} (flying and handling qualities) and C_9 (human factors).

Finally, it should be emphasized that the aforementioned criteria constitute the group of relevant criteria which should be taken into account in order to preserve the security or decrease of risk during the training, to extend this work, a further study regarding additional relevant criteria, such as economic aspects or even institutional factors, should be carried out.

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