CHOOSING OPTIMIZATION PROCESS IN THE EVENT OF FLIGH PLAN INTERRUPTION WITH THE AID OF NETWORK ANALYSIS PROCESS

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Abstract

In the world today, superior industry is one that makes balance between its capabilities and demands of customer. This requires organization's knowledge of customer, and their demands. In this research, a process-oriented process was proposed for choosing optimized process by managers of aviation industry in the event of interruption of flight plan. In first stage, interrupting factors of flight plan were described together with solutions to reduce them. Then, effect of each of these factors on interruption as well as on chosen options were collected from experts using paired comparison questionnaires, by geometrical average of combination and the outcomes were analyzed using network analysis process. The results included effect of each factor on interruption of flight plan together with weight of each option for decision making. In the end, based on the obtained results, proper decisions to be adopted in the event of interruption were proposed. This research shows that technical defect and delayed arrival are among the most important interrupting factors of flight plan, and notice of delay, cancellation, and replacement of route were among the most important decision instances faced by managers in aviation industry in the event of interruption of flight. Also, findings of this research show that because of fuzzy nature of this method, ambiguity resulting from verbal variables in experts' opinions regarding

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relation between factors of interruption and optimal decision in the event of interruption of flight is significantly reduced.

Keywords: interruption of flight plans, decision making, network analysis process

1. Introduction

In recent years, popularity of air travels has made aviation industrial into an effective industry in the world economy and transportation management [2],[7]. Statistics provided by international organizations show that many people prefer air travel to other methods today for such reasons as time limitations [1]. Yet, in recent years, some problems have challenged this industry. One of such problems is interruption of plan of aviation companies [6], [10]. Generally, flight planning includes design of flight plan, assignment of fleet, allocation of flight route and network, and assignment of flight crew [13]. The most important goal of flight planning constitutes reducing operational-manpower costs, and increasing profit of airlines. The main priority in flight planning is to attend capabilities and limitations of airlines [8]. Statistics show that many airlines lose a major part of their budget and time due to interruption of flight plan [6], [7] and [10]. In this research, factors of interruption of flight plan together with decision making solutions were identified using survey forms and interview with experts. Next, paired comparison questionnaires were used to calculate and rank effect of factors on interruption and individual options using network analysis method. People express rank and priority of the said options using verbal statements such as high, low, average, etc. verbal statements are obscure due to subjective values and personal opinions; for this reason, for ranking effect of individual factors of interruption of flight plan and options available to managers of company to be chosen in these events, combined method based on multifactor decision making was used. This type of decision making is an efficient method to prioritize available options and exact ranking based on conditions because it uses concepts of fuzzy theory. [3], [7] and [11]

3. Research Background

As far as the author knows in this area, no specific research has been conducted in Iran. In most of domestic researches, flight plans have been discussed by different methods, and no specific research is found on decision making in the event of interruption of flight planning process. Among the most important such researches are:

- Afandizadeh and Fazeli (2008) published a research titled mathematical modeling of flight planning of passenger airplane in international engineering journal of university of science and technology. [3]

- Alavi and Saffarzadeh (2009) published a research titled flight planning using heuristic optimization method in Modarres research paper. [14]

- Jarrah and Krishnamurti (1993) published a research titled a framework for support of decision making on delay and cancellation of airlines flights in transportation science journal. [2]

- Barnhart and Jiang (2009) published a research titled dynamic planning for airlines in transportation science journal. [5]

- Yen and Beirg (2006) published a research titled provision of an accident-based programming method to solve problem of planning for flight crew in transportation science journal. [9]

- Barnhart and Cohn (2004) published a research titled planning scheduling of airlines, achievements and opportunities in management of production operation and service journal. [4]

4. Principles of network analysis process

Thomas Saati (1996) proposed a method for multifactor decision making called network analysis process. Network analysis process is a comprehensive and multifunctional method for decision making, which is widely used in solving complex decision making problem. This process creates a general framework in which he highlighted dependence between higher elements on lower elements and interdependence of elements. This model was created to fill the gap of lack of establishment of connection between elements and standards in hierarchical model, and was based on formation of a network of connections, dependences, and links between elements and clusters. [12]

4.1. Stages of network analysis process

- Stage one, identification of factors and standards affecting decision making

- Stage two, decomposition of problem into a network including objectives, standards, sub-standards, and decision options

- Stage three, designing paired comparison questionnaire based on Saati's scale.

- Stage four, study of consistency of paired comparison matrix

- Stage five, production of non-weighted singular matrix

- Stage six, production of weighted singular matrix

- Stage seven, production of adjusted singular matrix

- Stage eight, taking the correct choice

If the super-matrix obtained in stage three covers the whole network, weight of different options and elements of different clusters may be found in respective columns of limit matrix, and if the super-matrix does not cover the whole network, and only include internal relations between clusters, the similar calculations must continue until final priority vector of options is extracted.

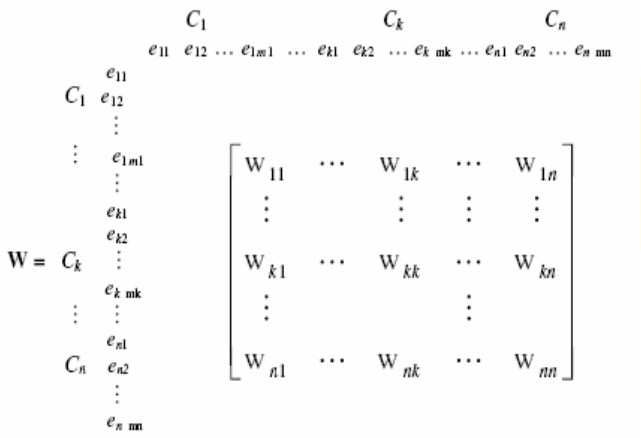

Figure 1. Standard view of supermatrix

4.2. Weighting methods

In network analysis method, the weighting methods are as follows:

- Ordinary least square method
- Logarithmic least square method
- Eigenvalue vector method
- Approximate methods

The following methods can be used to obtain Eigenvalue vector of matrix:

- Approximate method
- Row sum method
- Column sum method
- Geometrical average method
- Arithmetic average method

In network analysis model, the final result of weights is calculated in two ways:

- First method is like hierarchical analysis process, in which final weight of clusters is multiplied by the weight of elements and options according to formula to obtain final weight.
- Second method which is method and main basis of network analysis method is to use super-matrix; so that, dependence matrix, and independence matrix of clusters, elements and options

are placed in their proper place, and final weight is calculated using mathematical operation. Also, one can use Super-decision software to speed up process of constructing thee matrices and calculation of final weights. [3] , [12]

4.3. Use of network analysis process

- Step one, using data collected from questionnaire No. 1, the most important interrupting factor of airlines flight plan and decisions adopted in such situation are as follows:

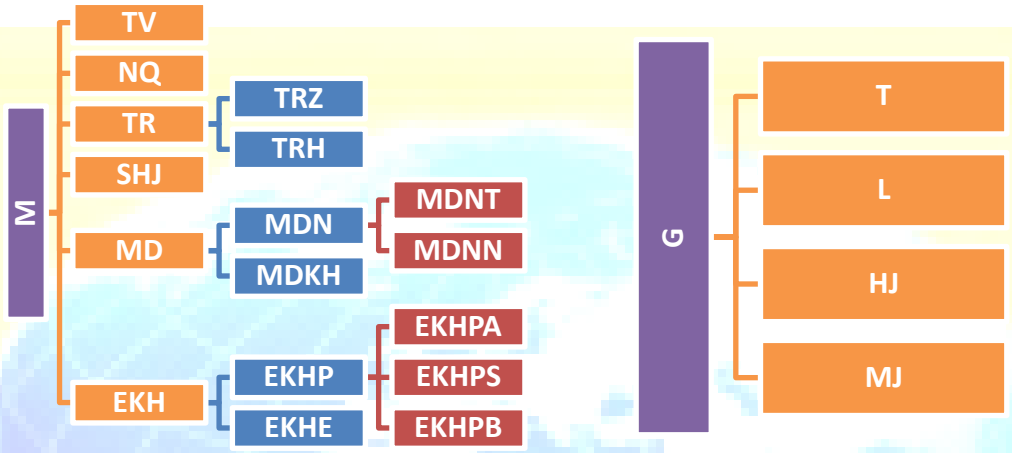

Figure 2. Problem structure

Table 1. Problem structure

Factor	Explanation	Factor	Explanation	Factor	Explanation	Factor	Explanation
M	Criteria	TRH	Air traffic	EKH	Specific causes	G	Decisions
TV	Delay Arrival	MD	Internal problems	EKHP	Support Problems	T	Flight Delay
NQ	Technical	MDN	Fleet problems	EKHPA	Preparation problems	L	Flights Canceled
SHJ	Weather Conditions	MDNT	Effects Of Sanctions	EKHPS	Fuel problems	HJ	Aircraft Replacement
TR	Traffic	MDNN	Repair&Maintenance	EKHPB	Security problems	MJ	Route Replacement

TRZ	Ground traffic	MDKH	Crew Problems	EKHE	Legal hours of flight crew

According to data collected from experts, in addition to said items, a series of effects exist in the problem, listed below, which convert the problem from a hierarchical one into a network one:

- Effect of all standards on arrival delay
- Effect of standards of weather conditions and internal problems on airport traffic standard
- Effect of arrival delay standards, airport traffic, and technical defect on standard of internal problem
- Second step, designed network for problem in Super-decision software is as follows:

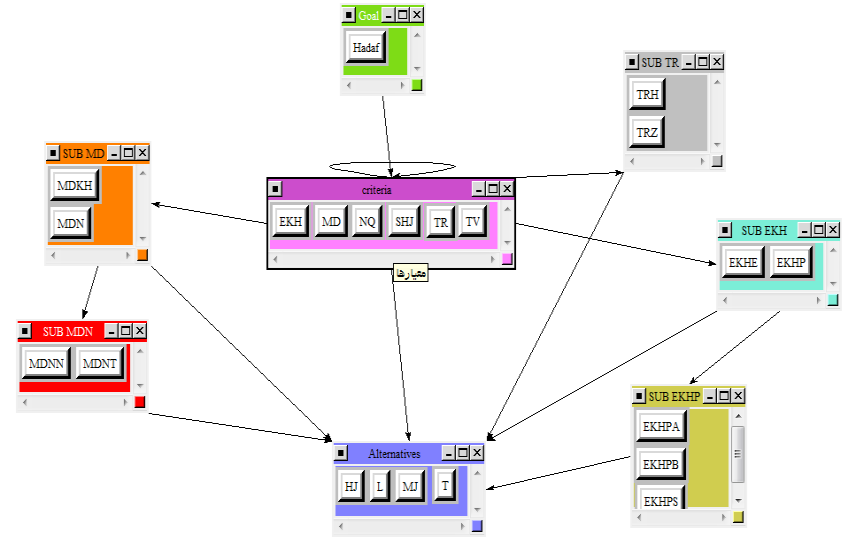

Figure 3. designed network for problem in Super-decision software

- Third step, first, each expert was asked to express opinion on each of the following items based on Saati scales and according to tables of questionnaire 2:
- Level of effect of each standard on the objective, which determines weight of each standard on achievement of the objective.
- Level of effect of each of the following standards on respective standard, which results in determination of weight of each of substandards on respective standard.

Table 2. Saati scale for verbal variables

Completely better	Intermediate	Much	Intermediate	Better	Intermediate	Slightly	Intermediate	Equal preferenc

9	8	7	6	5	4	3	2	1
Completely	Intermediate	Much	Intermediate	Worse	Intermediate	Slightly	Intermediate	Equal preferenc
0.111	0.125	0.14	0.167	0.2	0.25	0.333	0.5	1

Arithmetic average of experts' opinion calculated using combination geometrical average and then each row of geometrical average table and from column of geometrical average. Finally, geometrical average of each row was divided by arithmetic sum of geometrical average row. Obtained figures constitute Eigenvalue vector column, which indicates level of effect of individual standards on the objective. It is evident that sum of elements of Eigenvalue vector column is always equal to one.

- Fourth step, consistency of paired comparisons matrices may be obtained manually or using Superdecision software. Given inconsistency rate of comparisons matrices is below 0.1, one can make sure of consistency of comparisons. As a result, there will be no need for secondary comparison.

- Fifth step, non-weighted singular matrix is obtained by union of Eigenvalue vectors obtained from comparison of elements within a matrix. In this matrix, each column consists of several categories, each of which indicates Eigenvalue vector of paired comparisons of that category with respect to standard and control standard above that category. To create non-weighted singular matrix, first, Eigenvalue vectors of comparison of internal and external elements of the problem must be calculated manually or using superdecision software.

- Sixth step, in non-weighted singular matrix obtained in previous step, some columns may not follow the main principle of probability; in other words, sum of some column may not be equal to one. In this condition, final effect of intended standard has not been properly and accurately applied to all elements of columns. To prevent such situation, the following procedure is followed using results from comparison of categories under each standard:

Multiplication of normalized values corresponding to each standard with respect to effect of itself, and final normalization of columns

The outcome of this operation is weighted singular matrix.

- Step seven, Saati demonstrated that if we assume W to denote weighted matrix, the final weight of options, based on principles of probability matrices and Markof chain, is obtained using relation below:

$$\lim_{K\to\infty}(W)^{2K+1} \quad (1)$$

To obtain adjusted matrix, one can multiply the matrix by itself consecutively, so that rows are adjusted in a number, which is the very final weight of option. Also, one can obtain adjusted matrix using Superdecision matrix. Given this matrix produced by union of Eigenvalue vectors of problem is a huge 22×22 matrix, weight, non-weight and adjusted matrices are not discussed in this chapter.

- Step eight, after adjusted singular matrix was obtained, value of each row is replaced by respective option, and on this basis, the option which has acquired the highest weight is identified and selected. Finally, based on calculations, two following tables are obtained:

Table 3. Priority of each of standards over objective

	TV	NQ	SHJ	TR	MD	EKH
Priority	0.262	0.293	0.143	0.069	0.192	0.041

Table 4. Effect of each standard on each option

	TV	NQ	SHJ	TR	MD	EKH
T	0.611	0.354	0.173	0.415	0.340	0.514
L	0.067	0.113	0.215	0.130	0.380	0.241
HJ	0.190	0.485	0.045	0.087	0.080	0.123
MJ	0.132	0.048	0.567	0.367	0.200	0.122

Final priority of each selected option was obtained using respective rows in singular matrix. Final priority of options is presented in the table below.

Table 5. Final priority of each option obtained by network analysis method

	T	L	HJ	MJ
Priority	0.353	0.313	0.139	0.195

Also, to make sure of accuracy of calculations, final priority of each option was obtained using superdecision software.

Table 6. Final results of model using superdecision software

Name	Ideal	Normal	Raw

T	1.00000	0.353089	0.280027
L	0.885408	0.312628	0.247939
HJ	0.393222	0.138842	0.110113
MJ	0.5535520	0.195442	0.155001

Raw column is directly extracted from constructed supermatrix. Also, in case model has subnetworks, sum of ideal column of all subnetworks constitutes the raw column.

Ideal column, values of this column are obtained by dividing the number corresponding to each option by the largest number in raw column or the same number related to selected option.

Normal column, values of this column is obtained by dividing numbers of this option in raw column by sum of numbers existing in this column. Findings of table 5 show that results of manual calculations largely match the results from software.

5. Discussion and conclusion

In previous sections of this research, a comprehensive review of the literature and background of similar researches, and study of survey forms, paired questionnaires, and interview with experts, main factors of interruption of flight plans as well as decisions faced by managers of aviation industry in such events were obtained. Then, using network analysis method, effects of standards with respect to main objective, as well as effect of individual standards on choice of each selected option were calculated. In the beginning, hypotheses proposed were investigated, and then the results obtained from data analysis were dealt with, and finally, recommendations for improvement of decision making in the event of interruption of flight plan were provided.

5.1. Conclusion

5.1.1. Results obtained from study of effect of standards on objective

Using network analysis process and considering relations between standards, the most important factors of interruption of flight plans are technical defect and arrival delay. Using this process, effect of flight traffic factors and specific factors was obtained to be trivial. Also, effect of weather conditions and internal problems was at average level. This indicates that there is fundamental difference between what is stated by managers of aviation industry and facts and observations of this industry. In other words, managers of aviation industry do not consider the effects of such factors as weather condition to be very high and those of internal problems, and technical defect not to be very effective. This research shows the opinions of aviation industry do

not match the facts very much. However, such mismatch is partly natural, because many behaviors and effects of standards on each other are networked and interwoven, and it is not possible to understand them under normal circumstances.

5.1.2. The results from study of weight of each selected option for decision making

The results from network analysis show that the most proper decision making options in the event of interruption of flight plan are respectively notice of delay, notice of cancellation, followed by alternative route and airplane replacement options. These results show that most managers of aviation industry believe that in most cases notice of departure delay is the best decision in the event of interruption. On the other hand, contrary to opinion of many managers who strongly avoid cancellation of flights, the results of this research show that of the conditions are not good, it is better to cancel flight instead of notice of frequent and long delays. One of advantages of use of option of notice of cancellation is prevention of occurrence of network delays, and consecutive arrivals and departures. However, managers must pay enough attention to effects and consequences of cancellation decisions. In process of survey in this research, option of replacement of airplane in studied conditions is not a good option to choose. This shows that managers and experts consider this option with a special optimism without considering limitations and insufficiencies of capabilities and fleet. However, looking at what is actually performed, it is revealed that this view has not gone beyond theory, and in practice, managers avoid choosing the said options.

5.2. Recommendations

5.2.1. Recommendations resulting from research

Based on the result of the research, managers and experts in the field of aviation industry are advised to:

- First consider the basic and main causes of interruption when making decision regarding proper treatment of interruption of flight plan, because optimal decision is only possible if made based on the cause(s) of interruption.

- Consider the effect of cause(s) on occurrence of the current condition fairly and impartially without exerting their merely personal opinion when making decision.

- Consider capabilities and resources of the industry, including manpower, facilities, etc, so that decisions which are not proportionate to resources are avoided when making decision.

- Often, what comes from research or scientific methods for decision making do not match what manager(s) has in mind. In this case, it will be beneficial to make a decision which is a combination of experience of managers and results from scientific methods.

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