Research on Civil Aviation Security Management System in Dealing with Air Security Threats

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Abstract: Civil aviation encounters various security threats in the air and requires an agile and accurate response from the security management system. Based on this background, based on the uncertainty attribute of the air target security threat problem, this paper proposes a security chest air security threat assessment method based on the combined weighting method of analytic hierarchy process and entropy determination method, and establishes the threat based on interval estimation. Finally, the paper proves the accuracy of the method by example analysis, can effectively reduce the error of air security threat evaluation, and has a certain guiding role for the correct scientific decision of the air security system.

1. Introduction

The airborne target threat assessment is an important part of the prevention of accidents in civil aviation flights. It ranks the threat levels of all air targets, prioritizes the objectives, and provides advice for aviation security management system decision-making [1]. At present, fuzzy comprehensive evaluation method, analytic hierarchy process, MADM ranking method, interval number evaluation and other methods [2-4] are used to evaluate the threat degree of air targets, and some results have been achieved. The common feature of these methods is that they are influenced by human factors when determining the weights of evaluation indicators, so the requirements for evaluation experts are higher. However, for a specific problem, there is no guarantee that the weights of the indicators given by the experts are the same. On the contrary, in most cases, there are differences and even contradictions, resulting in the final evaluation results are not true and reliable. To this end, the paper proposes a comprehensive and positive method, using the entropy method to comprehensively eliminate the subjectivity of the analytic method to achieve a correct assessment of air security threats, and provide a certain guide for the rapid scientific decision-making of the civil aviation air security management system.

2. Analysis of factors affecting air target threat assessment

Treating pilots and controllers as a whole, based on four factors that affect the safe operation of air traffic, namely personnel control, external facilities, aircraft status and the external environment. The threats that require space management and collaborative management can be divided into: (1) subjective threats; (2) external threats; (3) aircraft state threats; (4) environmental threats.

2.1 Subject threat B1

Taking both sides of the open space as a whole, the research subjects include the two main bodies of pilots and controllers. The main threats mainly include the threats caused by the work errors of the main bodies, the threats caused by the language communication obstacles, and the threats caused by the mismatch between the two working procedures, such as the controller calling the wrong flight number, conducting non-standard land and air calls, and the pilot's command rehearsal error, operating the aircraft is not aligned with the course, etc. Because of their own work mistakes or violations of the rules will affect the operation of air traffic and the other party cannot change, that is, pose a threat to the other party.

Because both sides of the air and space have different requirements for ensuring air traffic operations, they often only focus on their own business needs and lack the necessary business communication. Pilots and controllers lack a more comprehensive understanding of each other's operational standards, job characteristics, work procedures, operating environment and conditions, and the information needs to complete tasks. The mismatch between the two working procedures poses a threat to both sides of the air. If the controller's hydraulic system failure guarantee procedure is not considered, the pilot needs a longer five sides to form a stable approach.

2.2 External threat B2

The external threat of air traffic operations comes from hardware and software facilities outside the space of thousands of pilots and controllers, which increases the complexity of pilot operations and controller command. For example, unreasonable airport layout, non-stop construction, entry and exit procedures, navigation facility failures, and other user airspace activities. Unreasonable design of the entry and exit routes increases the controller's monitoring load and the pilot's operational load. The failure of the navigation facility leads to the degradation of the approach procedure and affects the navigation accuracy. Pilots perform unfamiliar non-precision approach procedures that increase the risk of a controlled flight into terrain. The controller needs to provide more monitoring of the flight path of the aircraft, and a larger safety interval between the aircraft in the non-precision approach, which increases the notification and coordination between the control units and between the control and the flight load.

2.3 Aircraft status threat B3

From the local and overall considerations, aircraft state threats can be divided into single aircraft state threats and air traffic overall situation threats. Although both sides of the air and space focus on and manage the individual and group status of the aircraft, the state of the aircraft poses a threat to pilots and controllers both macroscopically and microscopically. If the pilot does not realize that the severity of air traffic congestion may result in fuel shortage, the controller may not be able to understand the climb performance of the aircraft's air/full load, which may result in less than a specified interval between the aircraft. These threats must be coordinated by the vacant land to avoid it.

2.4 Environmental threats B4

In addition to the pilot and controller's work space, environmental threats that need to be coordinated by the air and space include: complex weather, radio interference, ground obstacles, bird activities, and so on. Radio interference increases the difficulty of calling volume and listening commands; the low cloud and low visibility of the airport are not only easy to cause the pilot to misjudge, but also lead to the failure of the approach, and it is easy to affect the visual observation of the tower controller and increase the possibility of runway intrusion. Bird activity near the airport increases the complexity of regulatory command and aircraft operations.

3. Application of analytic hierarchy process and entropy method in air safety threat index evaluation system

3.1 Analytic hierarchy process to determine indicator weights

Assuming that the element *B* of the previous layer is used as a criterion, it has a dominant relationship with the elements *B1*, *B2*, ..., *Bn* of the next level. The establishment of the judgment matrix is to assign the corresponding weights of *B1*, *B2*, ..., *Bn* according to their relative importance under criterion *B*, that is, to repeatedly weigh the importance of criterion *B*, the two elements *B1* and *B2*, and here we need to use the 9-point ratio [5]. The scale assigns importance to importance. If the factor i is compared with j by a_{ij}, the factor j is compared with i and judged as $1/a_{ij}$. The consistency test is performed on the evaluation results using the formula (1), and the formula is as follows.

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{1}$$

Then determine the indicator weights, there are formulas as follows.

$$\overline{w}_i = n\sqrt{\prod_{j=1}^{n} a_{ij}} \qquad (i = 1,2,3...,n) \tag{2}$$

Then, the normalized judgment matrices are added by columns according to formula (3), and then the entire column vector is normalized to obtain the normalized relative importance of the elements relative to the upper layer criterion.

$$w_i = \frac{\overline{w}_i}{\sum_{i=1}^{n} \overline{w}_i} \qquad (i = 1,2,3...,n) \tag{3}$$

Calculate the weight of each dimension of the criteria layer relative to financial performance, and obtain Table 1.

Table.1. Air security threat indicator judgment matrix and weight

A	B1	B2	B3	B4	W
B1	1	1/2	1/2	4	0.20
B2	2	1	3	1/2	0.35
B3	2	1/3	1	4	0.16
B4	4	2	1/4	1	0.29

Consistency test results: *lmax* = 6.329; *CI* = 0.0658; *RI* = 1.24; *CR* = 0.0531 < 0.1.

3.2 Entropy method to determine the index weight

(1) Raw data standardization processing. Converted as follows:

$$x_{ij} = \frac{\max_i \{a_{ij}\} - a_{ij}}{\max_i \{a_{ij}\} - \min_i \{a_{ij}\}} \qquad (i = 1,2,3...,n) \tag{4}$$

In the formula, $\max_i \{a_{ij}\}$ and $\min_i \{a_{ij}\}$ respectively represent the maximum value and the minimum value among all the evaluation objects under the same indicator.

(2) Calculate the characteristic weight of the i-th evaluated object under the j-th index.

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \qquad (i = 1,2,3...,n) \tag{5}$$

(3) Calculate the entropy value A of the j-th index, with the expression:

$$e_j = -(\ln n)^{-1} \sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{6}$$

If $p_{ij}=0$, define $\lim_{p\to 0} p_{ij} \ln p_{ij} = 0$. If x_{ij} is equal for a given j, then $p_{ij}=1/n$, then $e_j=1$. Where n is the number of objects to be evaluated and m is the number of indicators.

(4) Calculate the difference coefficient of index x_j. The greater the difference coefficient $q_j = 1 - e_j$, q_j more attention should be paid to the role of this indicator.

(5) Determine the weight. Using the entropy value to calculate the objective weighting expression of each indicator is:

$$w_j = q_j / \sum_{j=0}^{m} q_j \qquad (j=0,1,2...,m) \tag{7}$$

According to the above steps, the weights of the civil aviation security management system in response to the indicators under the airborne security threat assessment system are obtained, as shown in Table 2.

Table.2. Entropy weight method to determine the index weight of security threat assessment system

A	B1	B2	B3	B4
W	0.35	0.33	0.21	0.11

3.3 Comprehensive weight determination

The weights obtained by the analytic hierarchy process belong to subjective weights, and the weights obtained by the entropy method belong to objective weights. In order to make the weight of each indicator more scientific and reasonable, this paper will combine the above two methods to determine the weight of indicators in each dimension and each dimension layer, as shown in Table 5.

Table.3. Fuzzy comprehensive index weights determined by entropy determination method and analytic hierarchy process

A	B1	B2	B3	B4
Entropy weight method weight	0.35	0.33	0.21	0.11
AHP weight	0.2	0.35	0.16	0.29
Comprehensive weight	0.275	0.34	0.185	0.2

4. Measures and opinions to strengthen response to air security threats

4.1 Strengthen cross-industry training and exchanges of air-ground personnel to enhance their own quality and collaboration capabilities

Improving the effectiveness of "people" and the degree of matching between "people" and "people" is the key to the effectiveness of the open space. Because pilots and controllers are mainly engaged in the theoretical knowledge and job skills of the profession during the initial training phase of the college, as well as during job training and re-training, there is a great lack of learning about each other's knowledge, procedures and skills [6]. Not only that, the vacant land and the two sides pay too much attention to the accuracy of their own operating procedures, and neglect the cooperation between the two parties. Therefore, a joint training system for cooperation and coordination between flight crews and control teams should be established. The content of joint training includes: mutual understanding of each other's normal working procedures and special handling procedures, familiarity with the threats, classification and management methods of errors and undesired situations that need to be coordinated, and focus on the key links that are prone to mismatch. And pay more attention to the work, so as to reduce the occurrence of insecurity caused by improper cooperation. Through joint training, pilots and controllers are made aware of the importance of air-ground cooperation and the ability to collaboratively manage threats, errors and undesired conditions. Understanding each other and trust is the foundation of synergy. Both sides of the vacant land should take joint training as an opportunity to enhance exchanges and mutual trust, so that the interface between "people" and "people" is more consistent, providing each other with positive and friendly support, so that the effectiveness of both sides can be maximized.

4.2 Focus on the layout and optimization of the open space cooperation program

In order to strengthen the concept of pilots and controllers cooperating to manage threats and errors, and to improve management capabilities, in addition to increasing the input and strength of joint training, both sides of the open space should also combine the working characteristics of the two parties to formulate matching work procedures and air-ground cooperation specifications.

Standards, including laws and regulations, rules and regulations, operation manuals, operating procedures, checklists, special handling procedures, emergency rescue procedures, etc. Both parties should revise and improve relevant regulations and standards according to the actual needs of the vacant land in operation, optimize operational procedures, improve checklists and work orders, and revise operational manuals. The air traffic control department should focus on optimizing the effective interconnection of various types of aircraft special handling procedures and regulatory work procedures under abnormal conditions [7]. Through program matching, both sides of the airspace improve their ability to manage threats, errors, and undesired conditions.

4.3 Strengthen the sharing and analysis of safety information

In recent years, airlines and air traffic control departments have checked their daily operational status from route operation safety audit and normal operation safety monitoring to obtain operational and safety data for statistical analysis. The collection of aviation safety related information is carried out independently by the departments of flight, air traffic control, aircraft maintenance, and operation control, and lacks connection and sharing. The incompleteness of information data directly affects the identification of risk elements in the coordination of open space. Both parties need to use a variety of methods to obtain various types of safety information data from various sources, and build a space-integrated safety information database based on the TEM framework to provide supporting data for quantitative research. Through statistical analysis of data, the safety risk factors of air-ground cooperation are obtained, and more targeted risk identification and management are realized [8].

4.4 Integrate open space into the threat and error management framework and conduct corresponding review work

Because space coordination helps reduce threats and errors in operation, and facilitates the identification and management of threats and errors, it can be incorporated into the regulatory framework. In the flight operation quality monitoring, normal operation safety monitoring, safety inspection, focusing on and improving the air-ground cooperation link, the airlines and air traffic control departments will adopt comprehensive measures at different levels such as personnel training, technical improvement and regulatory improvement to effectively strengthen the open space.

5. Conclusion

Air-ground coordination is an effective means of managing threats, errors and undesired conditions. The TEM model based on open space coordination emphasizes the interaction between open spaces and the coordinated management of threats, errors and undesired conditions by pilots and controllers. Mutual cooperation based on mutual familiarity, information sharing and collaboration is the key to managing threats, errors and undesired conditions in operation. Not only that, but also need to continuously improve the system strategy based on the management of threats, errors and undesired situations based on air-ground management from the organizational level, and accelerate the promotion of air-ground integration into the threat and error management framework by means of management. The example proves that this method effectively solves the problem of target threat assessment and has a wide application prospect. For the problem of uncertain multi-attribute decision making, many solutions have been proposed, but the rationality, effectiveness and error of each scheme are worthy of further study.

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