



Evaluation and Analysis of Basic-Level Aircraft Maintenance and Support Capabilities

Yanli Gao¹✉, Shaokang Ji¹, Jianling Qu¹, and Mingran Li²

¹ Qingdao Branch of Naval Aviation University, No. 2, Siliu Middle Road,
Qingdao 266000, China
gaoyanli2003@163.com

² School of Electrical Engineering, University of Jinan, No. 336, Nanxinzhuan West Road,
Jinan 250022, China

Abstract. This paper provides a scientific evaluation of the basic-level aircraft maintenance and support capabilities. According to the principles of objectivity and representativeness, one evaluation index system is selected and constructed, and then the weight of each index is determined by the analytic hierarchy process combined with the Delphi method. Using the fuzzy comprehensive evaluation method, the basic-level aircraft maintenance and support capabilities evaluation model is constructed and applied. The analysis and verification results show that the model can effectively evaluate the basic-level aircraft maintenance and support capabilities.

Keywords: Aircraft maintenance · Support capabilities

1 Introduction

Maintenance and support capabilities are the abilities to ensure a good completion of maintenance tasks, which is of great significance to the flight safety of aircraft. In recent years. With the smooth and well progress of the reform process, our army's new aircraft have continued to enter the working list, and the demand for aviation equipment maintenance and support has increased. For this reason, it is necessary for us to carry out an evaluation of aircraft maintenance and support capabilities. The results of the evaluation can help the development plan of the army and are of great significance to improving the combat effectiveness of the army. This paper conducts an evaluation study on the aircraft maintenance and support capabilities at the basic-level.

Considering the actual situation of basic-level aircraft maintenance and support activities, taking basic-level aircraft maintenance and support capabilities as the research object, based on the construction of an index system, using analytic hierarchy process, Delphi method, and comprehensive evaluation techniques to study the basic-level aircraft comprehensive evaluation model maintenance and support. Later, we analyse the security maintenance capabilities barrier system maintenance and support tasks to complete, and then pointed out that according to the results reflected in the constraints of the basic-level and maintenance and support the existence of the phenomenon and to suggest improvements.

2 Constructing the Index System

To evaluate basic-level aircraft maintenance and support capabilities, we must first construct an evaluation index system, which is an important basis for carrying out evaluation activities. This paper follows objectivity, hierarchy, representation, independence of the principles to construct the evaluation index system. It uses Delphi method to screen evaluation indices, the expert group on screening results given by consulting the relevant experts to summarize the collective opinion, after several soliciting opinions, feedback and adjustments, analysis and sorting out relatively unified results (Table 1).

Table 1. Basic-level aircraft maintenance and support capabilities evaluation index system

Target layer	First level indices	Secondary level indices	Index type
Basic-level aircraft maintenance and support capabilities	Maintenance human resources A1	Professional allocation rate B11	Quantitative
		Locomotive maintenance style B12	Qualitative
		Professional technical level of personnel B13	Qualitative
		Personnel exchange status B14	Qualitative
	Maintenance facility equipment A2	Facilities and equipment types matching rate B21	Quantitative
		Allocation rate of equipment and facilities B22	Quantitative
		Facility equipment maintenance level B23	Qualitative
		Facility and equipment safety level B24	Qualitative
	Spare parts equipment guarantee A3	Spare parts equipment matching rate B31	Quantitative
		Spare parts equipment supply capacity B32	Qualitative
		Spare parts equipment storage level B33	Qualitative
		Integrity rate of spare parts and equipment B34	Quantitative
	Information resources A4	Operation card completeness B41	Qualitative

(continued)

Table 1. (continued)

Target layer	First level indices	Secondary level indices	Index type
		Completeness of maintenance image data B42	Qualitative
		Completeness of equipment technical data B43	Qualitative
		Applicability of equipment technical data B44	Qualitative
	Organizational management level A5	Perfection of rules and regulations B51	Qualitative
		Division of powers B52	Qualitative
		Maintenance training situation B53	Qualitative
		Aircraft maintenance culture construction level B54	Qualitative

3 Determining the Weights of the Evaluation Indices

In the comprehensive evaluation, each index in the evaluation index system has a large or small effect on the evaluated object, and its importance is different. Therefore, it needs to be weighted. Weight is a numerical value that measures the degree of influence of each index relative to the evaluated object. In the process of comprehensive evaluation, determining the weight of each evaluation index is a very sensitive and critical link, because whether the weight is reasonable or not will be directly determined. Affect the reliability of the evaluation results.

This paper chooses the analytic hierarchy process combined with the Delphi method as the method to determine the index weights in the basic-level aircraft maintenance and support capabilities evaluation work, and the Delphi method is used to construct the decision matrix. The realization process is shown in Fig. 1.

According to the constructed decision matrix to solve the weight of each index, this paper adopts the sum method, and the specific solution is as follows:

Assume A is a decision matrix, each column is normalized to get $B = (b_{ij})_{n \times n}$, where

$$\bar{b}_{ij} = \frac{b_{ij}}{\sum_{k=1}^n b_{kj}} \quad (i, j = 1, 2, \dots, n) \tag{1}$$

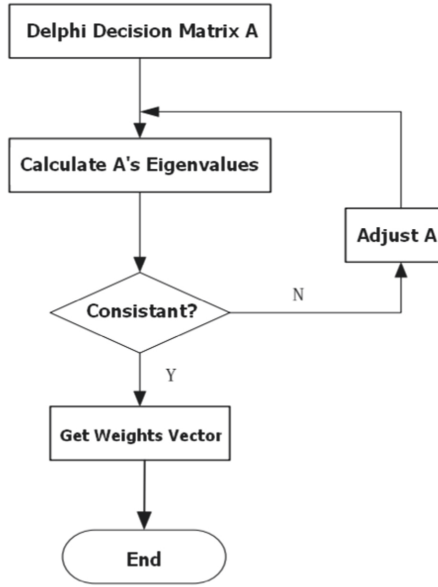


Fig. 1. AHP-Delphi empowerment flow chart

Then conduct addition by rows to get the vector $C = (c_1, c_2, \dots, c_n)^T$, where

$$c_i = \sum_{j=1}^n b_{ij} \quad (i = 1, 2, \dots, n) \tag{2}$$

After normalization of $C = (c_1, c_2, \dots, c_n)^T$, the weight of each index is obtained:

$$w_i = \frac{C_i}{\sum_{k=1}^n C_k} \quad (i = 1, 2, \dots, n) \tag{3}$$

The comparison results obtained by the Delphi method may be contrary to the original intention or self-contradictory, which will cause the consistency of the decision matrix to deviate. Therefore, to ensure the reliability of the determined weights, the matrix must be checked.

First, find the largest characteristic root of the decision matrix:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{(Aw)_i}{w_i} \tag{4}$$

The quantitative index used to measure the degree of consistency is called the consistency index, which is generally represented by CI:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{5}$$

In previous work, it has been introduced that there are five first-level indices under the basic-level aircraft maintenance and support capabilities T, which are maintenance human resources A1, maintenance equipment and facilities A2, spare equipment support A3, information resources A4, and organizational management level A5, which are now determined the five-level indices right weight, the expert scoring results in Table 2.

Table 2. T-Ai decision matrix

T	A1	A2	A3	A4	A5
A1	1	3	2	5	8
A2	1/3	1	1/2	3	5
A3	1/2	2	1	4	7
A4	1/5	1/3	1/4	1	3
A5	1/8	1/5	1/7	1/3	1

According to the formula (1), we first normalize each column of the matrix to obtain:

$$B = \begin{bmatrix} 0.4633 & 0.4592 & 0.5138 & 0.3750 & 0.3333 \\ 0.1544 & 0.1531 & 0.1284 & 0.2250 & 0.2083 \\ 0.2317 & 0.3061 & 0.2569 & 0.3000 & 0.2917 \\ 0.0927 & 0.0510 & 0.0642 & 0.0750 & 0.1250 \\ 0.0579 & 0.0306 & 0.0367 & 0.0250 & 0.0417 \end{bmatrix}$$

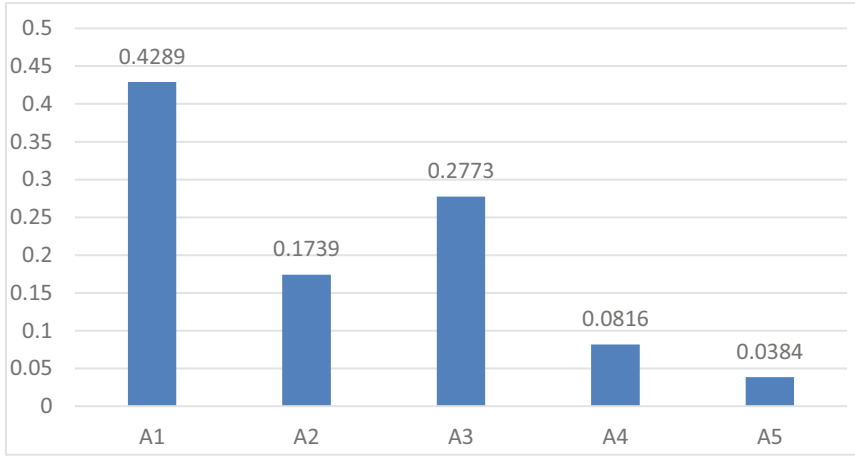
Later, sum the matrix B by rows to get C:

$$C = \begin{bmatrix} 2.1446 \\ 0.8693 \\ 1.3863 \\ 0.4079 \\ 0.1919 \end{bmatrix}$$

Normalize the matrix C to obtain the weight of each index at the first level

$$w_T = \begin{bmatrix} 0.4289 \\ 0.1739 \\ 0.2773 \\ 0.0816 \\ 0.0384 \end{bmatrix}$$

The following is the consistency test of the decision matrix of T-Ai



$$AW = \begin{bmatrix} 1 & 3 & 2 & 5 & 8 \\ 1/3 & 1 & 1/2 & 3 & 5 \\ 1/2 & 2 & 1 & 4 & 7 \\ 1/5 & 1/3 & 1/4 & 1 & 3 \\ 1/8 & 1/5 & 1/7 & 1/3 & 1 \end{bmatrix} \begin{bmatrix} 0.4289 \\ 0.1739 \\ 0.2773 \\ 0.0816 \\ 0.0384 \end{bmatrix} = \begin{bmatrix} 2.2200 \\ 0.8921 \\ 1.4344 \\ 0.4098 \\ 0.1936 \end{bmatrix}$$

Thus, maximum eigenvalues are:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{(Aw)_i}{w_i} = \frac{1}{5} \sum_{i=1}^5 \frac{(Aw)_i}{w_i} = 5.1094$$

Consistency index value

$$CI = \frac{\lambda_{\max} - n}{n - 1} = \frac{5.1094 - 5}{5 - 1} = 0.0273$$

By looking up the table, we know that the correction value of the fifth-order matrix is RI = 1.12, then CR = CI/RI = 0.0273/1.12 = 0.0244 < 0.1, indicating that the decision matrix has passed the test and has good consistency.

4 Constructing a Comprehensive Evaluation Model

This work uses fuzzy method to construct the evaluation model.

4.1 Construction of Domain of Factors

Domain of factors $U = \{u_1, u_2, \dots, u_n\}$ within which factors the assessed object is composed of and u_n means the n -th evaluation index.

4.2 Construction of Domain of Comment Levels

The domain of comment levels $V = \{v_1, v_2, \dots, v_m\}$ is a collection of various evaluation results of the evaluated object, which is used to describe the state after the evaluation of each factor, that is, to define each interval of the state of the evaluated object. Among them, it represents the total number of state intervals. People usually use appropriate vocabulary to describe the comment levels of different situations. For example, to evaluate the risk levels of epidemics in various regions, you can use $V = \{\text{high risk, medium risk, low risk}\}$ to describe. For this paper, to evaluate the basic level aircraft maintenance and support, we can use $V = \{\text{excellent, good, fair, bad}\}$ to describe, and then assign the corresponding score interval to this comment.

4.3 Construction of Fuzzy Relation Matrix R

Individually evaluate the underlying factors that affect the evaluated object to obtain the fuzzy relationship matrix R :

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} \tag{6}$$

where r_{ij} ($i = 1, 2, \dots, n; j = 1, 2, \dots, m$) represents degree of the i -th factor in the U domain belonging to the j -th element of the V domain. Generally, we have the rule that $r_{ij} = \frac{\text{the number of people whose } u_i \text{ is } v_j}{\text{total number of people who participated in the evaluation}}$. After normalization like this, the matrix R has no dimensions, and there is no need to further process the matrix.

4.4 Multi-factor Fuzzy Comprehensive Evaluation

Next, the calculated fuzzy weight vector W and the corresponding fuzzy relationship matrix R are integrated. This integration requires a suitable synthesis operator and gives the result vector Z of each evaluated object. The result vector Z is used to represent the degree to which each evaluated object belongs to the domain of each comment level

from the overall point of view. The formula model of fuzzy comprehensive evaluation is as follows:

$$Z = W \circ R = (w_1, w_2, \dots, w_n) \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} = (z_1, z_2, \dots, z_n) \quad (7)$$

To evaluate the results more intuitively, it is necessary for vector Z to be addressed. That is, to put it into a specific overall score by mathematical calculations. The method of processing vector Z generally uses the maximum membership rule and the weighted average rule. As the maximum membership rule only uses the maximum value of $z_i (i = 1, 2, \dots, m)$ and cannot fully utilize other information brought by Z, the result is relatively unneutral, while the weighted average rule can evaluate the result vector Z is integrated with the parameters of the comment rating domain, so that the final evaluation result is more scientific **Error! Reference source not found.** Therefore, this paper uses the weighted average vector of the Z.

4.5 Selection of Composition Operator

When integrating the weight vector and fuzzy relationship matrix of each evaluation index of the basic-level aircraft maintenance and support capabilities, the choice of composition operator is very important. Different composition operators correspond to different evaluation models, and the resulting evaluation results are also different. Each is different. In this paper, the $M(\bullet, \oplus)$ operator can be used to balance the weight of all factors and fully reflect the essential characteristics of the evaluated object.

$$z_j = \min \left\{ 1, \sum_{i=1}^n (w_i \cdot r_{ij}) \right\}, j = 1, 2, \dots, m \quad (8)$$

5 Application and Analysis

to be able to accurately evaluate the aircraft maintenance and support capabilities of the maintenance organization, based on the construction of an evaluation index system, this paper combines the analytic hierarchy process and the Delphi method to determine the weights of indices at all levels, and uses FCE for comprehensive evaluation to construct basic-level aircraft maintenance and support capabilities integrated evaluation model, evaluation and analysis of the maintenance organization, as shown in Fig. 2.

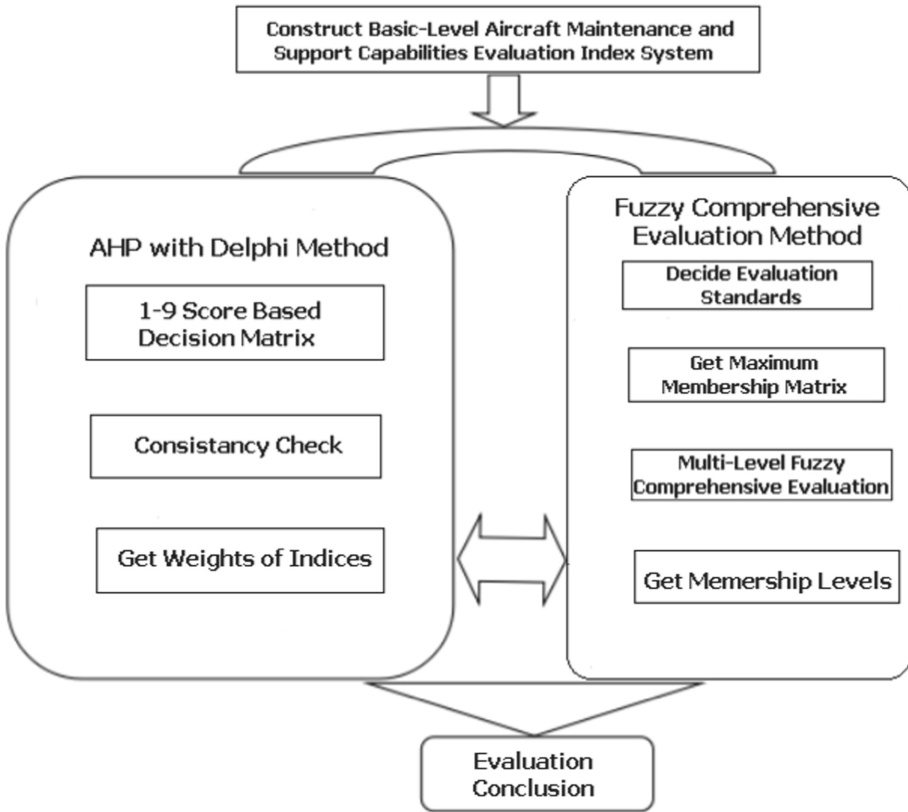


Fig. 2. Basic-level aircraft maintenance and support capabilities evaluation system model

The experiments include 15 officers of the unit to judge the actual situation of the evaluation indices, equipment maintenance and support personnel, including experts, ordinary employees and so on, the final evaluation of the results of statistical results of evaluation indices are shown in Table 3.

The fuzzy relationship matrix of maintenance human resources:

$$R_{A1} = \begin{bmatrix} 8/15 & 1/3 & 2/15 & 0 \\ 13/15 & 2/15 & 0 & 0 \\ 7/15 & 8/15 & 0 & 0 \\ 1/3 & 3/5 & 1/15 & 0 \end{bmatrix}$$

Fuzzy relationship matrix of maintenance equipment and facilities:

$$R_{A2} = \begin{bmatrix} 7/15 & 1/3 & 1/15 & 2/15 \\ 4/15 & 3/5 & 2/15 & 0 \\ 7/15 & 8/15 & 0 & 0 \\ 3/5 & 4/15 & 2/15 & 0 \end{bmatrix}$$

Table 3. Basic-level aircraft maintenance and support capabilities evaluation basic information collection form.

Evaluation items	Evaluation results	Comment Level			
		Excellent	Good	Normal	Bad
Maintenance human resources	Professional allocation rate	8	5	2	0
	Locomotive maintenance style	13	2	0	0
	Professional technical level of personnel	7	8	0	0
	Personnel exchange status	5	9	1	0
Maintenance facilities and equipment	Facilities and equipment types supporting rate	7	5	1	2
	Facility equipment quantity allocation rate	4	9	2	0
	Facility equipment maintenance level	7	8	0	0
	Facility and equipment safety	9	4	2	0
Spare parts equipment guarantees	Spare parts equipment matching rate	5	9	1	0
	Spare parts equipment supply capacity	6	8	1	0
	Spare parts equipment storage level	9	6	0	0
	Intact rate of spare parts and equipment	5	8	2	0
Information resources	Operation card completeness	12	3	0	0
	Completeness of repair image data	6	7	1	1
	Completeness of equipment technical data	13	2	0	0
	Applicability of equipment technical data	13	2	0	0
Organizational management level	Perfection of rules and regulations	13	2	0	0
	Division of powers	12	3	0	0
	Maintenance training situation	8	7	0	0

(continued)

Table 3. (continued)

Evaluation items	Evaluation results	Comment Level			
		Excellent	Good	Normal	Bad
	The level of maintenance culture	4	9	2	0

Fuzzy relationship matrix of spare parts equipment guarantee:

$$R_{A3} = \begin{bmatrix} 1/3 & 3/5 & 1/15 & 0 \\ 2/5 & 8/15 & 1/15 & 0 \\ 3/5 & 2/5 & 0 & 0 \\ 1/3 & 8/15 & 2/15 & 0 \end{bmatrix}$$

Fuzzy relationship matrix of information resources:

$$R_{A4} = \begin{bmatrix} 4/5 & 1/5 & 0 & 0 \\ 2/5 & 7/15 & 1/15 & 1/15 \\ 13/15 & 2/15 & 0 & 0 \\ 13/15 & 2/15 & 0 & 0 \end{bmatrix}$$

Fuzzy relationship matrix of organizational management level:

$$R_{A5} = \begin{bmatrix} 13/15 & 2/15 & 0 & 0 \\ 4/5 & 1/5 & 0 & 0 \\ 8/15 & 7/15 & 0 & 0 \\ 4/15 & 3/5 & 2/15 & 0 \end{bmatrix}$$

The calculated index weights are as follows (Table 4):

Table 4. Weights of each evaluation index

Target layer	First level indices	Weights	Secondary level indices	Weights
Basic-level aircraft maintenance and support capabilities	Maintenance human resources A1	0.4289	Professional allocation rate B11	0.5681
			Locomotive maintenance style B12	0.1333
			Professional technical level of personnel B13	0.2410
			Personnel exchange status B14	0.0576

(continued)

Table 4. (continued)

Target layer	First level indices	Weights	Secondary level indices	Weights
	Maintenance facility equipment A2	0.1739	Facilities and equipment types matching rate B21	0.2083
			Allocation rate of equipment and facilities B22	0.1010
			Facility equipment maintenance level B23	0.0480
			Facility and equipment safety level B24	0.6427
	Spare parts equipment guarantee A3	0.2773	Spare parts equipment matching rate B31	0.4209
			Spare parts equipment supply capacity B32	0.1064
			Spare parts equipment storage level B33	0.0517
			Integrity rate of spare parts and equipment B34	0.4209
	Information resources A4	0.0816	Operation card completeness B41	0.1171
			Completeness of maintenance image data B42	0.0509
			Completeness of equipment technical data B43	0.2695
			Applicability of equipment technical data B44	0.5625
	Organizational management Level A5	0.0384	Perfection of rules and regulations B51	0.3273
			Division of powers B52	0.5359
			Maintenance training situation B53	0.0916
			Aircraft maintenance culture construction level B54	0.0453

Based on the obtained weights, the composite operator is used to integrate the weight vector and the fuzzy relationship matrix, and then the integration result is processed according to the weighted average method to obtain the scores of the evaluation results at all levels.

Maintenance human resources A1, according to the fuzzy transformation formula (7), we can get:

$$\begin{aligned}
 Z_{A1} &= w_{A1}^\circ R_{A1} \\
 &= [0.5681 \ 0.1333 \ 0.2410 \ 0.0576]^\circ \begin{bmatrix} 8/15 & 1/3 & 2/15 & 0 \\ 13/15 & 2/15 & 0 & 0 \\ 7/15 & 8/15 & 0 & 0 \\ 1/3 & 3/5 & 1/15 & 0 \end{bmatrix} \\
 &= [0.5502 \ 0.3702 \ 0.0796 \ 0]
 \end{aligned}$$

The evaluation result vector of maintenance facilities and equipment A2 is:

$$\begin{aligned}
 Z_{A2} &= w_{A2}^\circ R_{A2} \\
 &= [0.2083 \ 0.1010 \ 0.0480 \ 0.6427]^\circ \begin{bmatrix} 7/15 & 1/3 & 1/15 & 2/15 \\ 4/15 & 3/5 & 2/15 & 0 \\ 7/15 & 8/15 & 0 & 0 \\ 3/5 & 4/15 & 2/15 & 0 \end{bmatrix} \\
 &= [0.5322 \ 0.3270 \ 0.1130 \ 0.0278]
 \end{aligned}$$

The evaluation result vector of spare parts equipment guarantee A3 is:

$$\begin{aligned}
 Z_{A3} &= w_{A3}^\circ R_{A3} \\
 &= [0.4209 \ 0.1064 \ 0.0517 \ 0.4209]^\circ \begin{bmatrix} 1/3 & 3/5 & 1/15 & 0 \\ 2/5 & 8/15 & 1/15 & 0 \\ 3/5 & 2/5 & 0 & 0 \\ 1/3 & 8/15 & 2/15 & 0 \end{bmatrix} \\
 &= [0.3542 \ 0.5544 \ 0.0913 \ 0]
 \end{aligned}$$

The information resource A4 evaluation result vector is:

$$\begin{aligned}
 Z_{A4} &= w_{A4}^\circ R_{A4} \\
 &= [0.1171 \ 0.0509 \ 0.2695 \ 0.5625]^\circ \begin{bmatrix} 4/5 & 1/5 & 0 & 0 \\ 2/5 & 7/15 & 1/15 & 1/15 \\ 13/15 & 2/15 & 0 & 0 \\ 13/15 & 2/15 & 0 & 0 \end{bmatrix} \\
 &= [0.8351 \ 0.1581 \ 0.0034 \ 0.0034]
 \end{aligned}$$

The organization management level A5 evaluation result vector is (Fig. 3):

$$\begin{aligned}
 Z_{A5} &= w_{A5}^{\circ} R_{A5} \\
 &= [0.3273 \ 0.5359 \ 0.0916 \ 0.0453]^{\circ} \begin{bmatrix} 13/15 & 2/15 & 0 & 0 \\ 4/5 & 1/5 & 0 & 0 \\ 8/15 & 7/15 & 0 & 0 \\ 4/15 & 3/5 & 2/15 & 0 \end{bmatrix} \\
 &= [0.7733 \ 0.2207 \ 0.0060 \ 0]
 \end{aligned}$$

According to a fuzzy calculation results, maintenance of human resources $Z_{A1} = [0.5502 \ 0.3702 \ 0.0796 \ 0]$, the table shows there are 55.02 percent of human resource evaluation of the maintenance personnel of the participating units for outstanding, 37.02% of eligible staff evaluated as good, as well as 7.96% of eligible staff evaluation in general, Draw a histogram of the evaluation result vector of each first-level index as shown in Fig. 4.

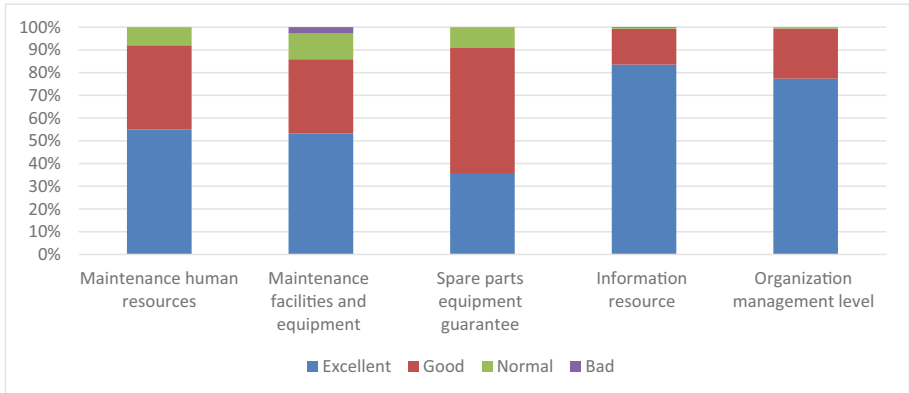


Fig. 3. First-level fuzzy comprehensive evaluation

According to the formula $S = Z \cdot V^T$, the total score of each first-level index can be obtained.

Maintenance human resources A1 total score:

$$S_{A1} = Z_{A1} \cdot V^T = [0.5502 \ 0.3702 \ 0.0796 \ 0] \cdot \begin{bmatrix} 95 \\ 80 \\ 60 \\ 25 \end{bmatrix} = 86.6610$$

Total score for maintenance facilities and equipment A2:

$$S_{A2} = Z_{A2} \cdot V^T = [0.5322 \ 0.3270 \ 0.1130 \ 0.0278] \cdot \begin{bmatrix} 95 \\ 80 \\ 60 \\ 25 \end{bmatrix} = 84.1939$$

Spare parts equipment guarantees A3 total score:

$$S_{A3} = Z_{A3} \cdot V^T = [0.3542 \ 0.5544 \ 0.0913 \ 0] \cdot \begin{bmatrix} 95 \\ 80 \\ 60 \\ 25 \end{bmatrix} = 83.4792$$

Information resources A4 total score:

$$S_{A4} = Z_{A4} \cdot V^T = [0.8351 \ 0.1581 \ 0.0034 \ 0.0034] \cdot \begin{bmatrix} 95 \\ 80 \\ 60 \\ 25 \end{bmatrix} = 92.2721$$

Organizational management level A5 total score:

$$S_{A5} = Z_{A5} \cdot V^T = [0.7733 \ 0.2207 \ 0.0060 \ 0] \cdot \begin{bmatrix} 95 \\ 80 \\ 60 \\ 25 \end{bmatrix} = 91.4869$$

Table 5. First-level evaluation result of each indices

Index	Result vector Z	Score S
A1	[0.5502 0.3702 0.0796 0]	86.6610
A2	[0.5322 0.3270 0.1130 0.0278]	84.1939
A3	[0.3542 0.5544 0.0913 0]	83.4792
A4	[0.8351 0.1581 0.0034 0.0034]	92.2721
A5	[0.7733 0.2207 0.0060 0]	91.4869

According to the evaluation result table, the indices with excellent evaluation results include information resources and organizational management level, and the indices with good evaluation results include maintenance human resources, maintenance equipment facilities and spare parts equipment guarantee.

The comprehensive evaluation can be done. According to Table 5, the target T fuzzy relationship matrix is:

$$R_T = \begin{bmatrix} Z_{A1} \\ Z_{A2} \\ Z_{A3} \\ Z_{A4} \\ Z_{A5} \end{bmatrix} = \begin{bmatrix} 0.5502 & 0.3702 & 0.0796 & 0 \\ 0.5322 & 0.3270 & 0.1130 & 0.0278 \\ 0.3542 & 0.5544 & 0.0913 & 0 \\ 0.8351 & 0.1581 & 0.0034 & 0.0034 \\ 0.7733 & 0.2207 & 0.0060 & 0 \end{bmatrix}$$

Then the result vector of the basic-level aircraft maintenance and support capabilities is:

$$\begin{aligned} Z_T &= w_T^\circ R_T \\ &= [0.4289 \ 0.1739 \ 0.2773 \ 0.0816 \ 0.0384]^\circ \begin{bmatrix} 0.5502 & 0.3702 & 0.0796 & 0 \\ 0.5322 & 0.3270 & 0.1130 & 0.0278 \\ 0.3542 & 0.5544 & 0.0913 & 0 \\ 0.8351 & 0.1581 & 0.0034 & 0.0034 \\ 0.7733 & 0.2207 & 0.0060 & 0 \end{bmatrix} \\ &= [0.5246 \ 0.3908 \ 0.0796 \ 0.0051] \end{aligned}$$

The result vector representation from an overall evaluation of the analysis, of which 52.46% of aircraft maintenance and support personnel of the participating units of the grass-roots level evaluation is outstanding, 39.08% of eligible staff evaluated as good, as well as 7.96% of eligible staff evaluation in general, while in addition, the remaining 0.51% is evaluated as poor.

According to the scores of the four evaluation levels $V = [95, 80, 60, 25]$, the final score of the fuzzy comprehensive evaluation of the basic-level aircraft maintenance and support capabilities can be obtained as:

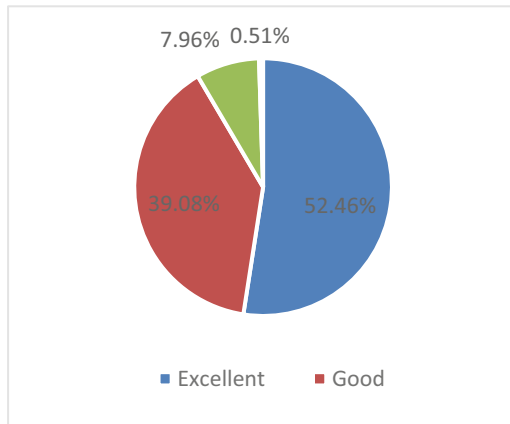


Fig. 4. Target layer evaluation results.

$$S_T = Z_T \cdot V^T = [0.5246 \ 0.3908 \ 0.0796 \ 0.0051] \cdot \begin{bmatrix} 95 \\ 80 \\ 60 \\ 25 \end{bmatrix}$$

$$= 86.0015$$

Finally, it can be concluded that the comprehensive score of basic-level aircraft maintenance and support capabilities is 86.0015 points, which is reflected in the evaluation as good and tends to be excellent. The evaluation result is basically consistent with the actual maintenance and support situation, which verifies the effectiveness of the evaluation model on the basic-level aircraft maintenance and support capabilities. According to the first-level index evaluation score, the unit performed relatively well in terms of information resources and organizational management level, while there is still room for improvement in the performance of maintenance human resources, maintenance equipment and facilities, and spare equipment support, which is mapped to the second-level. The indices are mainly the lack of the allocation of maintenance professionals, the level of maintenance technology, the matching of facilities and equipment, and the completeness of spare parts and equipment.

6 Conclusion

This paper first studies the comprehensive evaluation method. According to the constructed index system and the actual evaluation problem, the fuzzy comprehensive evaluation method is selected for evaluation. Later, the evaluation method is used to construct the evaluation model system. The system not only solves the basic-level aircraft maintenance and support capabilities evaluation and analysis problem but also provides conclusions and suggestions for improvement. The verification of the proposed method of this paper proves the feasibility of using the model system to solve the basic-level aircraft maintenance and support capabilities evaluation problem. It also provides a basis for basic-level aircraft maintenance and support evaluation.

References

1. Jie, L., Van Zuylen, H.J.: Road traffic in China. *Procedia Soc. Behav. Sci.* **111**, 107–116 (2014)
2. Zhao, S., Huang, B.: Trial-and-error or avoiding a guess? Initialization of the Kalman filter. *Automatica* **121**, 109184 (2020)
3. Zhao, S., Shmaliy, Y.S., Liu, F.: Fast Kalman-like optimal unbiased FIR filtering with applications. *IEEE Trans. Signal Process.* **64**(9), 2284–2297 (2016)
4. Wang, J.: Evaluation modeling on command capability of command organization. *Command Control Simul.* **38**(2) (2016)
5. Zhang, W., Yu, M.: A comprehensive evaluation of war injury care and treatment capacity in field medical facilities based on the analytic hierarchy process (AHP) method. *Mil. Med. Sci.* **41**(12) (2017)
6. Cao, C., Liu, J.: Evaluation method of POL support capabilities of naval aviation station in war. *J. Naval Univ. Eng.* **22**(5) (2010)